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LOCAL GOVERNMENT BOARD

(Medical Department).

REPORTS OF INSPECTOR OF FOODS.

No. 6.

ON PRESERVATIVES IN MEAT FOODS PACKED IN CANS OR GLASS.

[*Dr. A. W. J. MacFadden.*]

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Report by Dr. A. W. J. MacFadden to the Local Government Board on Preservatives in Canned and Glass-packed Meats of Home and Foreign origins, with observations on the Manufacture of such Meats.

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ARTHUR NEWSHOLME,
Medical Officer,,
May 26th, 1908.

TABLE OF CONTENTS.

The subject of this report is divided as follows :—

OCCASION OF INQUIRY ... ... p. 2

SECTION 1.—The practice of American manufacturers exporting to the United Kingdom, in regard to the use of preservatives in canned meats :—
- United States Meat Inspection Act ... ... p. 3
- Preservatives found in American canned meats (table) ... ... p. 5
  - Boron compounds and their significance in canned meats ... ... p. 5
  - Sulphites, their significance and estimation ... ... p. 6
- Varieties of American canned meats received in this country ... ... p. 7
- Inspection and sampling of products in American packing-houses ... p. 7

SECTION 2.—Presence of preservatives in raw materials of various origin which may be employed in the preparation of British-made canned and glass-packed meats :—
- A. Sources and varieties of raw materials :—
  - United States products ... ... p. 8
    - Boric acid in hams and bacon ... ... p. 9
      - Evidence given before Departmental Committee on preservatives p. 10
        - Examination of American hams as to penetration by boron preservatives ... ... p. 10
  - Canada ... ... p. 12
  - Denmark ... ... p. 12
  - United Kingdom ... ... p. 13
- B. Extent to which the use of raw materials which contain preservatives may account for the presence of preservatives in British-made canned meats :—
  - Practice as regards use of fresh raw materials ... ... p. 13
  - Preservative content of canned meats resulting :—
    - (A) From use of borax-packed tongues, &c. ... ... p. 14
    - (B) „ „ hams, &c. ... ... p. 14
  - Hams and bacon free from borax ... ... p. 15

SECTION 3.—The practice of home manufacturers in regard to the use of preservatives in canned and glass-packed meats (with some notes on the methods employed in home factories) :—
- Preservatives found in British canned and glass-packed meats (table) ... p. 15
- The addition of preservatives during preparation ... ... p. 16
  - Encouragement of practice by manufacturers of preservatives ... p. 17
- Manufacture of canned and glass-packed meats ... ... p. 18
  - Conditions of premises in their bearing on use of preservatives ... p. 18
  - Preparatory pickling of meats ... ... p. 19
  - Cooking, cutting and preparing ... ... p. 19

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Section 3—*continued.*
Packing in tin and glass ... ... p. 20
Types of containers, relative advantages compared ... ... p. 21
Tin containers ... ... p. 21
Glass containers ... ... p. 22
The Automatic cap ... ... p. 22
The Phœnix cap ... ... p. 22
Sterilization ... ... p. 23
Open vat process for cans ... ... p. 24
Retort process for cans ... ... p. 24
Sterilizing glass receptacles ... ... p. 25
High temperature as a cause of breakage ... ... p. 25
„ „ affecting appearance of meat ... ... p. 25
Criteria of sterilization by heat ... ... p. 26
Criteria usually taken ... ... p. 26
An improved system ... ... p. 27

SECTION 4.—General review and conclusion :—
(1) Preservatives in imported canned meats ... ... p. 28
Extent of protection afforded by foreign and colonial laws ... ... p. 29
(2) Preservatives in British-made canned and glass-packed meats ... p. 29
Derived from raw materials or added by the canner, circumstances affecting their presence ... ... p. 30
(3) Administrative considerations in regard to preservatives in canned and glass-packed meats ... ... p. 33
(4) Additional observations ... ... p. 33
(A) Proprietary antiseptic preparations ... ... p. 33
(B) Labelling ... ... p. 34
(C) Admixture of starch with potted meats ... ... p. 34
(D) Preservatives in sausages, &c. ... ... p. 34
(E) Places where food is prepared ... ... p. 34

ADDENDA :—
A. Boric acid content of borax-packed hams ... ... p. 35
B. Boric acid content of certain potted meats ... ... p. 37
C. Sulphites in Sausages ... ... p. 37

OCCASION OF INQUIRY.

During the summer and autumn of 1906 a large number of public analysts throughout the country received samples of canned and glass-packed meats, and in response to a request by Dr. Buchanan furnished special reports on the result of their examination of these foods. From these reports it was noticed that the percentage of samples in which preservatives were found was much higher than might have been expected having regard for the fact that the cans or glasses in which these articles were packed had been hermetically sealed and, presumably, sterilized by heat in the usual way. Out of a total of 1,733 hermetically sealed tins or glasses dealt with in the above mentioned returns, no fewer than 333, or over 19 per cent., were reported to contain chemical preservatives other than salt and saltpetre. Of these preservatives, 243 were boron compounds, forming 14 per cent. of the whole, and in the remaining 90 samples the presence of sulphite preservatives was reported.

In the case of meat foods of this kind it is generally understood that, with certain possible exceptions, there should be no need for the addition of chemical antiseptics at the time of preparation of the meat for canning, and that the meat which is canned should ordinarily be fresh meat, or cured meat—not meat which has been subjected to treatment involving the introduction of preservatives such as boric acid or sulphites. It is to be expected that meat foods of this kind which have been submitted to a process of sterilization in hermetically sealed containers should be sufficiently protected by these means from processes of decomposition so long as they remain unopened ; chemical preservatives are not required to further this object.

In these circumstances the use of preservative materials of the kind referred to appeared liable to objection, apart from any risk to health arising from consumption of the preservatives themselves, in that their presence pointed to the probability that by this means it had been sought to overcome undesirable conditions either in the meat itself or in the processes of its manufacture.

In view of these considerations the Board decided that some inquiries should be made into the circumstances which lead to the presence of preservative agents in this class of food, and for this purpose I was directed to make the necessary investigations.

My inquiries were made in the first instance among London representatives of the principal United States and Canadian packing houses, through whose hands the bulk of orders from wholesale and retail dealers in this country pass. I also had interviews with members of Chicago packing firms who were acquainted with the technical aspect of the canning trade in America. Secondly, I visited a number of canning factories in London and elsewhere and made inquiries regarding the sources from which the raw materials employed were derived, the arrangements which existed for their preparation, packing and sterilization, and the practice in the various factories as to the use of preservatives. Note was also made of the general conditions as to arrangements, orderliness, and cleanliness which were observed in each factory. In addition I made inquiries in various directions as to the liability of raw materials of home and foreign origin employed by these manufacturers, to contain preservatives.

I gladly take this opportunity of acknowledging my indebtedness to those British manufacturers and merchants whom I visited, for the assistance which they afforded me during my inquiry, and to the members and London representatives of American and Colonial firms, who supplied me with much valuable information on many matters referred to in this report.

Although the great bulk of canned meats imported by this country are derived from the United States, it would have been desirable, if circumstances had permitted, to have dealt in Section 1, under a comprehensive heading, with canned meats imported from other countries. These are practically all products of British Dominions—Canada, Australia, and New Zealand. But unfortunately for this purpose the reports of the public analysts, who were dealing with samples purchased from retailers, gave little information in regard to Colonial meats. In the case of United States products, the labels on the cans in most instances showed the country of manufacture. Colonial meats on the other hand are often labelled or re-labelled in this country, and the reports relating to meats which were clearly shown by the labels to be Colonial, were too few to enable any useful deductions to be made from them.

SECTION 1.

The Practice of American Manufacturers exporting to the United Kingdom, in regard to the use of Preservatives in Canned Meats.

United States Meat Inspection Act.—The occurrences which led to the passing of the Meat Inspection Act by the United States Legislature in 1906, made it specially desirable to ascertain, if possible, what might be the significance of preservatives found in American canned meats and reported in the returns of public analysts above referred to, and to discover how far this new law and the regulations thereunder were likely to affect the use of preservatives in American meat products intended for export to this country.

The Act in question, which came into force on 1st October, 1906, requires that "inspectors shall mark, stamp, tag or label as "Inspected and Passed" all such products found to be sound, healthful and wholesome, and which contain no dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food * * * * *Provided*, that subject to the rules and regulations of the Secretary of Agriculture, the provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specification or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to

be exported; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of all the other provisions of the Act."

Regulation 39 (*a*) under the Act, as amended by Amendment No. 6 of B.A.I. Order No. 137, requires that "No meat or meat-food product for interstate commerce, or for foreign commerce except as hereinafter provided, shall contain any substance which lessens its wholesomeness, or any drug, chemical, harmful dye, or preservative, other than the preservatives common salt, sugar, wood smoke, vinegar, pure spices, and, pending further inquiry, saltpetre. No dye, unless specifically authorised by a Federal statute, shall be used in any meat-food product prepared for interstate or foreign commerce, until the use of such dye has been specificially authorised by the Secretary of Agriculture . . . " But (*b*) " In accordance with the direction of the foreign purchaser or his agent, meats and meat food products prepared for export may contain preservatives in proportions which do not conflict with the laws of the foreign country to which they are to be exported." And, further, " When such meats and meat food products are prepared for export under this regulation they shall be prepared in compartments of the establishment separate and apart from those in which meats and meat food products are prepared according to paragraph (*a*) of this regulation, and such products shall be kept separate and shall be labelled with special trade labels, approved by the Secretary of Agriculture, and indicating that such products are for export only. Special export certificates will be issued for meats and meat food products of this character, and, if the products are not exported, under no circumstances shall they be allowed to enter domestic trade."

Consideration of the new law and regulations,* and particularly of the extracts quoted above, makes it clear that while consumers of American meat and meat food products in this country may share with the Americans themselves in whatever benefits are in practice derived from the new system of inspection as to initial wholesomeness of raw material and general soundness of the finished product, our position as regards preservatives and colouring matters is, so far as safeguards provided by American law are concerned, apparently much as it was before the enactment came into force. It is true that the United States Department of Agriculture have collected the laws and regulations of the various foreign countries regarding preservatives, and have cautioned their inspectors not to allow any meat or meat food product to be exported, if it contains a preservative forbidden by the laws of the country for which it is destined,† but the onus of protecting their inhabitants in this respect continues to rest, in the first place, with the Governments of the foreign countries themselves.

In the absence of official British standards of any kind, referring to preservatives in meat or meat food products, the legal obligations in this respect of American packer and Government inspector would appear from the foregoing to end, in the case of goods intended for the United Kingdom, when evidence was forthcoming that " the goods were prepared or packed according to the specifications or directions of the foreign purchaser."

In course of my inquiries among London representatives of United States packing houses (when I had also the opportunity of obtaining information on the points in question from members of Chicago firms) I was informed that it had never been the practice of American packers to add preservatives to meat for canning purposes, and that the addition of preservatives to canned goods intended for export, even when allowed by the new law, is not now practised, and has never been contemplated. In present circumstances it would, they said, be a matter of much inconvenience and loss to packers to put up canned goods containing preservatives in order to meet possible requirements of foreign purchasers; for not only would separate canning plants have to be established

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* While this report was passing through the Press, a new order (B.A.I. Order 150) was issued by the United States Department of Agriculture, revising the original regulations made under the Meat Inspection Act (B.A.I. Order 137). The changes made in the regulations do not appear to affect, in any essential respect, the questions discussed in this report.

† United States Department of Agriculture, Bureau of Animal Industry, Circular 101, by Geo. P. McCabe, Solicitor for the Department.

for this purpose, in accordance with Regulation 39 (*b*) of the Act above referred to, but the entire output of such plants would have to be earmarked for export only, an arrangement which would hamper American trade operations by cutting off foreign markets as a relief in times of surplus, and by rendering stock intended for those markets unavailable in times of shortage in the United States.

I was also told, and subsequent inquiries among British merchants go to confirm this statement, that, as a matter of fact, there was no demand in this country for preservatives in canned meats, and, it being the general opinion among American manufacturers that the use of chemical preservatives in hermetically sealed goods was quite unnecessary, there was, therefore, no reason whatever why American packers should wish to employ them. From these statements it would appear to be claimed that, so far as the use of preservatives is concerned, the new law has not affected the conditions under which the canned meat trade has been conducted with this country in past years.

It will be well, however, in this respect to note the findings of public analysts, as regards the canned meats of the firms in question, in the returns made to Dr. Buchanan in 1906. The occurrence of preservatives in these samples will be most conveniently shown by means of the following table :—

PRESERVATIVES FOUND IN AMERICAN CANNED MEATS : THEIR SIGNIFICANCE.

TABLE showing number of cases in which preservatives were reported in samples of canned meats manufactured by five different firms of United States packers.

Variety of Canned Meats	Total Samples examined.	Preservatives.	
		Boron.	Sulphites.
Corned beef	264	22	17
Tongues	91	11	4
*Prepared meats ...	82	8	7
†Fresh meats	67	4	3
Potted meats	57	1	5
Soups	14	1	1
Total	575	47	37

* Brawns, meat loaves, minced steak, canned sausage, &c..
† Roast beef, roast mutton, chicken, &c.

It should be remembered in connexion with the figures given that they represent results obtained by many analysts using different methods and with different criteria for reporting. It would seem that relatively small quantities of preservative have been reported by some analysts but not by others The table shows, however, that a considerable proportion of American samples examined were reported to contain preservative, either in the form of sulphites or of boron compounds.

Boron Compounds.—The quantities of boron compounds reported in the 47 American samples above mentioned were for the most part small, varying from "traces" to quantities estimated at 5 or 6 grains per pound. In a few instances the amounts estimated were somewhat greater than these, but in none was the quantity reported to exceed 25 grains per pound. The amounts in which boric acid appears to have occurred in the majority of these samples were indeed so small as to be of practically no preservative value to the contents of cans after packing, sealing and sterilization had been completed, and it is therefore extremely unlikely that the antiseptic found had been deliberately added with this object. Their presence, at any rate in amounts greater than mere traces, suggests rather that in the manufacture of these meats a mixture of raw materials might have been used, part of which had been treated with preservatives for some reason, while the remainder, which probably consisted of

the bulk of the meat, had not been so treated. The possible practice of sprinkling portions of meat with preservative, in order to keep them fresh until opportunity arose for using them, or the inclusion in a "boiling" of meat free from boric acid—*e.g.*, tongues—of some material which had been treated in pickle containing this preservative, suggested themselves. It is conceivable that meat treated with boric acid in either of these ways, when cooked along with larger quantities of materials not so treated, might account for small amounts of boric acid being ultimately found in canned meats made from such boilings.

Suggestions of this kind were, however, not admitted by any of the American representatives whom I saw. They all denied the possibility of preservatives having been employed, even before the occurrences and legislation of 1906, for purposes like these. If any meat were left over undealt with from one day to another, or from the end of one week to the beginning of the next, it would, they said, be placed in the refrigerators with which every canning establishment is well equipped. Surplus meat, for which there was no immediate use, would be dealt with in the same way. They also stated that the management of these canning establishments was conducted with the express object in view of getting the meat into the cans with the greatest possible despatch after slaughter of the animals, and that arrangements made for this purpose left little opportunity for meat to go wrong in the process and little necessity even for the use of refrigerators, once the process of manufacture had begun.

Certain explanations were, however, offered for the occurrence of these small quantities of boric acid in canned products. One was that part of the canning plant, *e.g.*, cauldrons, &c., might have become accidentally contaminated with boric acid from some of the pickling fluids. Another was the alleged presence of boric acid in the tissues of living animals grazed in certain Western States, such as Dakota and Utah, where the soil is reported to contain boron deposits. Appreciable quantities of boric acid are said to be capable of demonstration in the tissues of these animals immediately after slaughter, but it seems extremely unlikely that this source would account even for traces of boric acid, discoverable by ordinary methods, in canned meats made from such animals. The alleged frequent occurrence of boric acid as a natural impurity of salt which is used in the preparation of canned meats, was also referred to by American manufacturers as an unavoidable source from which traces of boric acid would be likely to gain entrance into these materials.

It should be noted that practically all the reports sent to Dr. Buchanan concerned samples which must have been manufactured at a date prior to the new law coming into force. At that time borax or boric acid was undoubtedly in common use in American packing and curing factories, and though the general rule may have been, as stated, that these substances were not employed in connexion with food intended for canning, it nevertheless seems unnecessary to go far afield for an explanation of their presence while there is so strong a probability that general rules of the kind, when not rigidly enforced by State regulations and supervision, would be subject to more or less frequent exception.

Sulphites.—Much of what has been noted respecting the significance of boric acid in canned meats also applies to these preservatives. The canning firms assert that sulphurous acid or sulphites have never been used by canners either in connexion with the preservation of meat or for any other purpose in their factories. On the other hand the advantages which the meat preparer may obtain for his business by the use of sulphurous acid and sulphites are well known. They may be used as spray or "pickle" to keep meat fresh, or to "revivify" and give a fresh appearance to meat which has already become stale, and it may be doubted whether the use of these materials was unknown in United States packing houses at a time when their methods of preparation were subject to no sort of supervision or official regulation. Use of these materials is now prohibited by American law in goods intended for domestic commerce, a circumstance which, as has been stated already, is said to be tantamount, in the case of canned goods, to universal prohibition.

Considerable doubt seems to exist in the minds of analysts as to the correct interpretation of results which suggest the presence, in small quantities at any rate, of these sulphur compounds in canned foods. On the one hand, it is believed that sulphurous acid, added to meat foods, can only be recognised as such by analysis in steadily diminishing amounts as the age of the meat increases. An experiment in illustration of this, which was conducted by Mr. Richards, is given in Addendum C. The diminution is no doubt due to the more or less rapid oxidation of the sulphites into compounds which are indistinguishable from the natural salts of the meat. For this reason it has been suggested that the actual quantity of sulphite found in an ordinary tin should be taken to indicate that a considerably larger quantity had been added to the meat in the first instance. On the other hand, it is contended that the reactions often relied upon by analysts as an indication of the presence of sulphites are not trustworthy for the purpose, as equivalent reactions in the absence of added sulphites may be obtained even in the case of apparently fresh meats. This is, I understand, the view taken by the analyst of one of the principal packing firms of Chicago, and his explanation of the amounts found by English chemists in American canned meats is based upon it. The subject is one which appears to require some further investigation in its chemical aspects.

Varieties of American canned meats received in this country.—In some respects American goods of this class, as a whole, possess an advantage over those made in this country in regard to the use of preservatives. The chief of these is the fact that American goods are invariably packed in cans, whereas a steadily increasing quantity of home products of the same kind is being packed in glass receptacles. The relative advantages attached to the two methods will be gone into more fully when dealing with the subject of home-produced canned meats ; but it may be stated here that sterilization of canned goods presents fewer difficulties, and can be more thoroughly accomplished, than is the case with glass-packed products. American canned meats imported into this country consist chiefly of corned beef, tongues, and other meats in large portions, besides brawns and the simpler forms of chopped meats such as the various so-called "loaves." The amount of what are generally known as "potted meats" sent by the United States is comparatively small. The term "potted meat" is here used to include pastes of all kinds, including fish pastes, *pâtés*, and the large variety of mixed meats such as "ham, tongue, and chicken," "chicken and ham," and other substances of the kind. The nature of the latter products, both as to the quality of meat from which they may be prepared and the manipulations necessary in their manufacture, render them perhaps more liable to contamination and putrefactive changes than most other forms of canned meat, and it is in their case that the necessity for adding considerable quantities of preservative before canning might more frequently arise. Among American "potted meats" reported upon in the returns made to Dr. Buchanan, however, preservatives were not found to occur more frequently, or in greater quantities than was the case with other canned meats of United States origin.

Inspection and sampling of products in American packing-houses.—The effect of the United States Meat Inspection Act, if strictly carried out, should be entirely to do away with the use of boron, sulphite and other antiseptics in United States packing houses where such products as canned meats, which are prepared indifferently for inter-State commerce or for export, are manufactured. In addition to prohibitory regulations, provision is also made by Regulation 39 (*a*) for officially testing samples of the finished products, as follows :—

"Inspection and sampling of prepared meats and meat food products, by department employees shall be conducted in such manner and at such times as may be necessary to secure a rigid enforcement of this regulation."

I am unable to say whether, as a result of inspection and sampling, such as is provided for by this paragraph, any rejections have been made on account of the presence of small amounts of preservatives attributable, as is alleged by American packers, to such accidental and unavoidable sources as those above referred to. None of the firms in question had knowledge of any such rejections.

It may be that the practice as regards preservatives now observed by American canners has the effect of conferring on consumers in this country the same protection which the Meat Inspection Act provides for the people of the United States. The position of British consumers in this respect is, however, due only in an indirect way to provisions of that Act, and, in the absence of British regulations in the matter, this position would seem to depend on the present practice continuing to be a convenient one for the canner. It will be prudent to remember that the value of the Meat Inspection Act as a whole to consumers in this country, entirely depends on the difference which in practice may exist between excellently drafted regulations and their systematic enforcement.

SECTION 2.

Presence of Preservatives in Raw Materials of various origin which may be employed in the preparation of British-made Canned and Glass-packed Meats.

A. *Sources and Varieties of Raw Materials.*

In many of the foreign countries and British Dominions from which large quantities of the meat supplies of this country are derived, chemical preservatives are not employed either in the preparation or packing of the meat products which are exported. Thus materials of this kind exported from Argentina, Australia and New Zealand are invariably preserved simply by one or other form of cold storage. It will not be necessary, therefore, to refer here to meats derived from these countries.

The great bulk of preserved meat, of the kind which comes under this section, is imported from the United States. Canada also sends a certain proportion, but this is small when compared with that of the former country.

UNITED STATES PRODUCTS.

In dealing with meat products treated with preservatives which come to this country from the United States, it should be remembered that the Meat Inspection Act and Regulations referred to in the preceding section, apply equally to these and to all other American meat food products. But the practice of United States packers and of British importers regarding the class of materials dealt with in this section, varies in important respects from that which has been indicated in the case of imported canned meats.

From inquiries which I have made it would seem that in the preparation for export of a large section of these products, advantage is now taken of that part of the Meat Inspection Act which allows of the use of preservatives in goods intended for exportation, provided the laws of the country for which they are destined permit of the use of preservatives in this way. Thus at the present date the following articles may still be treated with preservatives * for shipment to British markets in the same way as was the custom before the passing of the Meat Inspection Act, namely :—

Chopped sausage meat.
Kidneys in kegs.
Pigs' and other tongues in barrels.
Cooked tripe in kegs.
Uncooked tripe in barrels.

In addition to the above the following products, if not actually treated with boron compounds during their preparation, are, at any rate, packed in boron preservatives for shipment to the United Kingdom, and are liable to contain more or less preservatives in their substance on this account. These are :—

Green hams.
Green bacon.

---

* *Cf.* Dr. G. S. Buchanan's Report to the Local Government Board on certain Imported Meat Foods of questionable wholesomeness.—Reports of Inspector of Foods, No. 3.

These include the greater proportion of American hams and bacon entering British markets.

With the possible exception of the two kinds of tripe mentioned, all the other products named in the first list, are liable to be used by canners of one sort or another in this country. The objectionable nature of these food materials has already been dealt with fully in the report just referred to, and beyond stating the fact that their preservation during transit and for a more or less protracted period of storage in this country, is dependent entirely on the solutions of boron or other preservative in which they are placed, it will be unnecessary to refer to them in greater detail here.

Boric Acid in Hams and Bacon.

American hams and bacon, which are largely utilized by home canners in the preparation of various kinds of potted meats, arrive in this country packed in boxes, usually containing about 5 cwt. The hams, &c., are packed between thin layers of powdered borax in such a way as to be covered completely by the preservative. Cold storage is not required for the transport of these products when packed in this way, and they may be stored on landing in ordinary warehouses. American hams and bacon are generally shipped to this country in what is known as the "green" state, that is to say, they have simply been subjected to the preliminary process of pickling by one or another method, and have not been hung, smoked or otherwise finished for sale. The latter operations are carried out in the case of these American products by bacon and ham curers in this country. I understand that in the case of bacon and hams, American packers employ one of two different processes of curing preliminary to the despatch of these goods. One is known as "dry curing," and I am told that in this process salt and saltpetre alone are used, without any other preservatives. This I understand is the method employed by some Chicago firms, who make a speciality of the trade in "English cut" hams and bacon. The other is known as the "sweet pickle" method, in which the hams are steeped for a period of about four weeks in a liquid containing salt, saltpetre and sugar. I was informed by a director of a large association of American packers that rapid pickling by injection of fluid under pressure into the substance of the meat, as practised in Denmark, is not employed in the United States. He told me also that previous to the passing of the new law 1 per cent. of boric acid was nearly always added to pickle for the purpose of keeping it and its contents from "souring," but that since the new law came into force the addition of boric acid to pickling fluids had been discontinued in all cases, including pickle used for the preparation of goods intended for export. It would not, he said, pay the packers to make a distinction of this kind between hams and bacon intended for the American home market and those for export, as this would involve the provision of a separate plant for the latter, besides earmarking such products for one definite destination several weeks before a demand for them had arisen.

It is stated to be only in the treatment after curing, *i.e.*, in the packing, that a distinction is made between products intended for inter-State trade and those required for immediate export to British markets. The practice, which has been in existence now for many years, is to pack the latter in borax preservative, which will act as a surface protective and prevent the meat from becoming tainted while in transit. This method of transporting hams and bacon is regarded by importers as being of vital importance to the trade in these materials—green hams and bacon are, after all, little more than pork and are readily perishable articles. The use of cold transport as a substitute has, they say, been found impracticable* and excessively costly so far as it has been tried, and the old method of packing in salt is declared to be incompatible with the modern taste for mild cured, *i.e.*, comparatively saltless, bacon and hams.

The method of packing hams and bacon above referred to is carried out in the following way. After the meat has been removed from the pickling tanks or dry salting rooms, that which is required for export is removed to the separate

* *Cf.*, p. 12.

building* where packing in preservative for this purpose is conducted. It is there dried, powdered with borax, and packed in wooden cases, an extra sprinkling of the preservative being placed between each layer of meat. I am told that from four to five pounds of borax are used to each case of 560 pounds, *i.e.*, somewhat less than 1 per cent. by weight of the meat. I also learn that about three and a half pounds of preservative is generally removed from the contents of each case when they are unpacked in this country. This would leave from half a pound to one and a half pounds of the preservative originally added to be accounted for. In reality, however, this amount is more than the mere difference in weight would indicate, for when the preservative is added it is in the form of dry powder, but by the end of the three or four weeks during which the case has been in transit, the powder will have absorbed a certain amount of moisture from the meat and will generally then be found in the form of a cake or paste in which the relative proportion of actual borax would probably be much less than in the original powder.

Evidence given before Departmental Committee on Preservatives.—Whatever may be the actual difference in weight between the added and the recovered preservative, a proportion of this difference might be accounted for on the assumption that some of the preservative had penetrated into the meat. This question is referred to in the minutes of evidence taken by the Departmental Committee on preservatives and colouring matters.† It was denied by many trade witnesses that penetration of boron compounds into the meat resulted from packing it in this way, but these witnesses did not produce any analytical data to support their statements. Mr. Harald Faber,† Commissioner to the Danish Government, stated that analyses by Dr. Dyer of Danish bacon which had merely been dusted with borax to preserve it during transport, showed that the preservative was present only in the outer portions of the meat and that a slice cut a quarter of an inch further in did not contain it. In this case, however, the bacon was Danish and its transport to England would be only a matter of a few days, compared with the three or four weeks or more during which American products must of necessity remain in contact with the preservative.

Mr. Collingwood Williams in his evidence on this point,‡ in relation to both home and foreign hams, said that in cases where borax was only on the surface he had not found that it penetrated far into the meat. In these analyses he had always rejected the outer part, about a quarter to half an inch, and analysed what was in the centre.

Mr. J. M. Harris in his evidence§ described experiments made with a view to determining the penetrative power of borax used as an external preservative. Two gammons of bacon sprinkled with borax and allowed to remain in this condition for eight days were found to contain at the end of that time, 10·5 and 14·1 grains of borax per pound respectively. The portions analysed were said not to have been taken from the surface of the meat with which the borax had been in contact, but from the centre of the meat, right down to the bone. In a piece of fresh pork treated in the same way by the analyst who conducted these experiments for Mr. Harris a portion of the meat taken from the centre was reported to yield 10·0 grains of borax per pound. A Canadian gammon that was said to have been packed in borax, but in the curing of which preservative had not been used, was also reported to contain 12·6 grains of borax per pound.

Examination of American hams as to penetration by boron preservative.—In order to obtain more precise information as to the penetrative power of borax used as a packing material, arrangements were made for the collection and examination of a number of hams derived from various packing houses in the United States. By permission of the London representatives of the firms in

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* In the amended regulations referred to in the footnote on p. 4, Regulation 22, paragraph 2, permits, under certain restrictions, the use of the ordinary packing rooms of an establishment for the purpose of packing meat products in preservative for foreign trade.

† Report of Departmental Committee on Preservatives and Colouring Matters : Minutes of Evidence, 4,236.

‡ *Ibid.*, 5178.

§ *Ibid.*, 5968–78 and 6019–27.

question I was enabled to visit the wharves and warehouses where the cases containing these hams were stored, and to take samples from certain of the cases which I selected. The examination of the samples was undertaken by Mr. P. A. Ellis Richards, F.I.C., on lines which had been previously arranged, and the results which he obtained are set out in an addendum to this report (Addendum A). At the time when the samples were taken note was made of the marks and numbers which appeared on each packing-case from which a ham was removed, and these were referred to the American manufacturers with the question as to whether boric acid in any form had been used in the *curing* of the hams which they contained. The reply in each case was in the negative. Evidence in support of this statement, which forms part of the general assertion that borax is not now used in the curing of American hams or bacon, is to be found in the analysis of sample No. 7, an American ham which had been sent to this country packed in salt only. Boric acid was not found in any part of this ham.

In the light of this information the results obtained by Mr. Richards confirm the view that boric acid which has been in contact with hams for a period of three or four weeks or more does actually penetrate their substance to a very considerable degree, and disposes of the contention put forward by some of those engaged in the trade that penetration beyond the surface, except to the very smallest extent, does not occur in these circumstances. It disposes also of the further statement that any boric acid which might be present in the surface layers of the meat as a result of contact with packing materials, can easily be removed by washing and brushing in the ordinary way. Reference to Mr. Richards' report will show that all the sample hams dealt with were washed and brushed in this way before chemical examination was made, and that notwithstanding this treatment there were found in the skin covering the fat as much as from 13 to 24 grains of boric acid per pound, and in the outer half inch of the lean side of the hams, amounts varying from 19 to 45 grains per pound. Even after boiling in the way ordinarily employed in the kitchen, large amounts of boric acid were still observed to be present in the outer layers of the lean portions of two hams (samples 5B and 6B).

Below the surface layers and throughout the entire mass of the meat the preservative was demonstrated in varying quantities in every sample in which borax had been used for packing. In some, quite considerable amounts were found as far as from two to three inches from the surface, and even in the most remote parts of the muscular substance quantities varying from 2 to 15 grains per pound were noted.

The small amount of penetration which was observed in the large mass of fat forming the upper portion of the hams is worthy of note. The quantity of boric acid found in this situation was in all cases fairly constant, but in none did it reach as much as two grains per pound, notwithstanding the fact that the tissues in immediate contact with it, namely, the skin and muscle substance, showed a much greater proportion of the preservative.

Muscular tissue on the other hand appears to be liable to somewhat extensive penetration by boron compounds. The distribution of the preservative at various levels in the muscular substance, as set out under the heading " lean " in the table of analytical results, shows a fairly constant decrease in amount as the distance from the lean or lower surface of the ham increases. As the amount of boric acid in that part of the muscular substance immediately underlying the upper layer of fat is greater in every case than the amount in the fat itself, it seems probable that most of the boric acid found in the muscular tissue, which represents the bulk of the total boric acid found in the ham, is derived by penetration from the lean under surface.

Experiments illustrating the extent to which boric acid and borax, used as packing materials, can penetrate the substance of green and smoked hams have also been carried out in Germany by Dr. Eduard Polenske.* The results obtained point to the same conclusions as those which follow Mr. Richards' analyses. Polenske showed that penetration by both these substances occurs whether the hams have been previously smoked or not.

* Arbeiten aus dem Kaiserlichen Gesundheitsamte, vol. 19 (1902), p. 167.

It is probable that the amount of penetration which takes place in hams through contact with their borax packing varies directly with the length of time during which contact occurs. I have been informed by the firms which supplied the samples that the interval between packing and shipment was not likely in these instances to have been more than two or three days at the outside. It may be assumed from this and from the dates of shipment that the samples referred to in the table under numbers 1 to 4 inclusive had been packed in their cases for about four weeks at the time they were taken for analysis. The case which contained samples 6A and 6B was said to have been packed about a month earlier than the others, and had arrived in London about four weeks previous to my taking them. These hams may therefore be regarded as having been in contact with their borax packing for double the period of the other samples. On analysis the edible parts of hams 6A and 6B yielded somewhat larger proportions of boric acid than were generally found in the remaining samples.

The process of cooking does not seem to reduce the boric acid content to any very marked extent, judging by the figures obtained in samples 5B and 6B which were boiled previous to being examined.

The average amount of boric acid found in the edible portion of each ham is shown in the last line of the table of analyses. The comparatively small quantities of the preservative found in samples of the minced and mixed fat and lean in each case, is due in great measure to the very small boric acid content of the fat, which forms so large a component of the total mass in most hams.

Other countries from which we receive considerable quantities of hams and bacon are Canada and Denmark.

Canada.

An Act has recently been passed by the Canadian Legislature which has similar reference to the question of preservatives in meat and meat food products to that contained in the United States Law already considered. Certain meats of the class referred to in Dr. Buchanan's report* above mentioned are sent to this country from Canada. These chiefly consist of pork and beef trimmings and pigs' cheeks, which are preserved in barrels by means of boron or other preservative solutions for export to the United Kingdom, where they are sold to brawn and pie makers, cook shops, &c., and may also be used in the preparation of canned meats.

I have been informed by representatives of some Canadian firms which export large quantities of ham and bacon to this country, that no other preservatives besides salt and saltpetre are used in the curing of these materials in Canada. Others state that a certain percentage of borax is added to the pickling fluid in which their bacon and hams are treated during the curing process. A large proportion of both classes of Canadian hams and bacon are, however, packed in borax for shipment to this country in the same way as that described in the case of United States products, and would doubtless be affected in a similar manner. I understand that one Canadian firm makes a speciality of exporting its bacon and hams in chilled chambers, and thus avoids the necessity for using packing materials of any kind.†

Denmark.

There is no State law prohibiting the use of preservatives in meats or meat food products in Denmark, though certain municipalities in that country have powers enabling them to make regulations in this respect. I am, however, informed by Mr. Faber, the Commissioner for Denmark in this country, that no preservatives other than the usual salt, saltpetre, and sugar are now used in the cure of Danish hams and bacon exported to the English market. These products arrive in England encased in canvas wrappers, and no preservative or other form of packing material is found necessary during the comparatively

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* *Loc. cit.*, p. 8.

† *Cf.* p. 9. I have been unable to ascertain whether or not borax is used in the curing of these products. Samples have not been procurable owing, it is said, to temporary shortage of out-put in the Canadian factory.

short period they are in transit. I was enabled to take in London samples of the produce of 13 different Danish bacon and ham factories which were examined with a view to the detection of boron compounds, but the results were negative in all cases.

United Kingdom.

As regards bacon and ham of British manufacture no very definite information is available as to the extent to which preservatives are used in their cure. Although no separate figures appear in the report of the Departmental Committee on Preservatives and Colouring Matters which refer specially to the use of preservatives in British produce of this kind, repeated reference to the existence of this practice among manufacturers in the United Kingdom is to be found in the minutes of evidence accompanying the report.

One well-known English maker of canned and glass-packed meats informed me that he used only English and Irish hams and bacon of the best brands and that notwithstanding statements by the curers who supplied them that boric acid was not used in their preparation, a large percentage of these materials were found on analysis to contain boron preservatives. A chemist is constantly employed at this factory and examines samples of all the raw materials received there. This firm has a large export trade in potted meats, &c, and I was told that when orders were received from countries where laws are in force prohibiting preservatives in imported products of this kind, great difficulty was sometimes experienced in obtaining ham and bacon of the purity necessary to insure that goods manufactured from them would comply with this requirement. Orders, it was said, had sometimes to be delayed until ham or bacon that was specially cured for the occasion could be delivered.

The amounts of boric acid found in many of the deliveries of hams and bacon above mentioned, were, I understand, quite small (traces) and were said to be attributed by the manufacturers who supplied the meat to accidental causes, such as contamination of plant or pickling materials with borax which might at one time have been used in connexion with them, or to preservative material being conveyed, in the form of dust, from parts of the factory where preservatives were employed in the preparation of other materials, *e.g.*, sausages.

The same considerations might well be applied to explanations like the above as have already been applied to those of a somewhat similar kind put forward by American manufacturers to account for the presence of small quantities of this preservative in their canned meats (*cf.* p. 6). Where ordinary cleanliness is observed and adequate precautions are taken by manufacturers, the contaminations of bacon and hams attributable to such causes should be exceedingly small, and the quantities to which they might be expected to give rise in manufactured materials, *e.g.*, potted meats derived from them, still smaller.

Borax, I understand, is not used in the United Kingdom for mere purposes of packing and transit within the country.

B.—*Extent to which the use of raw material which contains preservatives may account for the presence of preservatives in British-made canned meats.*

Use of fresh raw material.—Inquiry at the various English canning factories which were visited showed that the great bulk of the raw material used in the production of canned and glass-packed meats such as beef, tongues, brawns, &c., in these establishments was either purchased fresh in local markets or was refrigerated or frozen meat imported from abroad. In neither of these cases are preservatives found under ordinary conditions in the raw material. Instances no doubt occur, and will be referred to later, where meats of the above kinds which have been kept too long, and may have been treated with preservative substances to prevent further decomposition, are purchased at cheap rates by packers of less reputable character. Such cases, however, from the nature of the transaction, should properly be included in the next section, which deals with the deliberate addition of chemical substances for the purpose of covering up defective operations by the canner.

Use of borax-packed tongues, &c.—Exceptions to the general rule are those meats imported in strong solutions of preservative, which have been referred to in the previous sub-section. The most extensively used of these materials for canning purposes are certain tongues, chiefly those of pigs, which, when packed, are included in the category of "breakfast" or "lunch" tongues. Several of the manufacturers whom I visited employed large quantities of these tongues, and the fact that they contained preservative seemed to be generally realised. One manufacturer discontinued the use of these boracised tongues after conviction had been obtained under the Sale of Food and Drugs Acts in regard to a sample which contained 67 grains of boric acid per pound. Other meats in this class are probably used to a very much smaller extent for canning purposes. They all appear liable to contain such large amounts of boric acid that they must be considered, for this reason alone, distinctly objectionable articles of food.

The case is somewhat different with the other large class of canned and glass-packed meats, namely, the potted meats, including pastes and *pâtés*, which are packed in hermetically sealed vessels. These materials consist of finely divided mixtures of a number of meats, such as chicken, ham, tongue, veal and game of different kinds. The ingredients may be combined in a variety of ways, and put up, sometimes with no great straining after accuracy, under the description of "chicken and tongue," "veal and ham," "ham, tongue and chicken," and so on; or they may be described as consisting of one material only, as "ham" or "wild duck" for example.

Most of the raw materials entering into the composition of potted meats are in the same position in regard to preservatives as those referred to in the first group, that is to say they are purchased as fresh or frozen materials by the manufacturer, and, if obtained from proper sources, should be free from preservatives when delivered to him. Some makers employ American canned meats, *e.g.*, tongue, for making certain of their potted meats. Individual tins of these substances do occasionally contain boric acid and other preservatives, but the amounts are generally small, and where, as is customary, the contents of a number of tins are mixed together in the mincing machine at one time, the percentage of boric acid contained in the mass would be so small as to be practically inappreciable.

Use of borax-packed hams, &c.—The only ingredients of potted meats which appear almost constantly to contain boric acid previous to their coming into the possession of the canner are hams and bacon, which for potting purposes are nearly always of American origin.

It is possible that in the past, the amount of boric acid which found its way from this source into such articles as potted meats, may have been greater than at present, when borax packing is the only source of borax in imported American hams. In some cases this quantity, augmented by borax derived from the packing material, might have been even considerable. It is highly improbable, however, that amounts in any way approaching those of the large figures which have been found in British potted meats,* should have been due to this cause. It should be remembered that only a certain proportion of potted meats contain ham or bacon, and that in the majority of these it is mixed, generally in equal parts, with one or more meats of another kind, which, as a rule, are not liable to contain preservatives. Moreover, in the cheaper brands of potted meats, a certain quantity of rice flour or other cereal, varying from 10 per cent. to 50 per cent., or even more, is almost invariably mixed with the meat which they contain. This circumstance would further reduce the relative amount of the boric acid content of such meats, which might be attributed to the use of borax packed hams in their preparation. It is, however, in such cheap potted meats that boric acid appears to be found most frequently in large quantities, such as 40 grains per pound and upwards.

If the amounts of preservative shown in Mr. Richards' analyses are taken as representative of what may be expected to occur in borax-packed American hams coming into this country, the extent to which potted meats are likely

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* *Cf.* p. 16.

to become contaminated from this source may be roughly estimated. On what would perhaps be a liberal allowance, 15 grains per pound may be considered an outside limit of the average boric acid content of a borax-packed ham. A single ham would, however, seldom be used in preparing potted meat materials, and a closer approach to the amount of boric acid likely to be present in potted ham from this cause, would be arrived at by taking the content of an average mass of this material manufactured from several hams. Judging from the analytical results referred to, an average mass of many American hams chopped up together would probably show a smaller quantity, *e.g.*, not more than eight or nine grains per pound.

Hams and bacon free from borax.—In one of the largest factories which I visited, where special care seemed to be taken to exclude traces of boric acid from canned and glass-packed meats, I was informed that salt-packed American hams only were used. These hams were guaranteed to be free from preservatives by the American firm which supplied them. Salt-packed hams, free from boron preservative, can now be readily obtained in the English market, and I understand that any increased demand made for them would be met at once by American and possibly by Canadian packers, and that their cost would be no greater than that of borax-packed hams. The objection which has been made to the salty flavour of hams packed in this way, where they are required for ordinary table use, does not appear to have the same importance when they are employed in the preparation of potted meats. It would seem, therefore, that manufacturers who wish to use American hams, and are at the same time desirous of guarding against the introduction into their goods of small quantities of boric acid from this source, might, with advantage, adopt the plan of purchasing those hams only which have been packed in salt.

American bacon, which is sometimes used in the preparation of potted meats, is subject to similar conditions. I understand that there would be no difficulty in obtaining salt-packed bacon even at the present time.

SECTION 3.

The Practice of Home Manufacturers in regard to the use of Preservatives in Canned and Glass-packed Meats.

(With some notes on the method employed in home factories.)

Some indication of the extent to which preservatives occur in canned meats manufactured in this country may be obtained from an examination of the reports received from public analysts in 1906. It has not been found possible to allocate to their several countries of manufacture all the samples there reported upon, owing firstly to the large number of cases in which no definite indication as to source appears to have been present on the label,* and secondly to the fact that some well-known English names appearing on these tins are not those of manufacturers, but of agents or middlemen in this country whose goods may be either of home or foreign origin.

In order therefore that the minimum of doubt might exist as to what goods were actually of home manufacture, it became necessary to select from the returns the reports on those samples only which bore names of British manufacturers of canned meats.

Hence the figures set out in the following table, though they may not include all the samples of British origin reported upon, are unlikely to comprise any appreciable number of samples that are not of home manufacture :—

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* This seemed to be the case more especially with those goods which, either from the nature of their contents, *e.g.*, rabbit, &c., or from the name of the brand quoted in the analysts' reports, were probably of Colonial origin.

TABLE showing occurrence of preservatives in canned and hermetically sealed glass-packed goods of British manufacture.

Class.	Total Samples.	Preservatives.	
		Boron.	Sulphites.
Corned beef	9	3	—
Tongues	33	10	3
Potted meats, fish pastes, &c.	196	118	2
Prepared meats, brawn, &c., meat loaves, canned sausage, ham, minced steak	56	22	1
Fresh meats, rabbits, &c., roast beef, roast mutton	24	—	5
Soups, broths, meat extracts, &c.	11	2	1
Fish	23	1	—
Total	352	156	12

The above table shows the large proportion of British samples taken in which preservatives were reported. The actual amounts estimated to have been present were in many instances also considerable. Thus of boric acid the amounts estimated were in 11 samples between 20 and 30 grains per pound, in 15 between 30 and 40 grains, in 5 between 40 and 50 grains. Nine samples contained larger quantities, viz., 55, 56, 71·5, 74·2, 91, 110, 114·5, 145·7, and 163·6 grains per pound respectively. In about 100 of the samples the amounts of boric acid estimated varied from a fraction of a grain up to 20 grains per pound, and in the remaining samples which were said to contain boric acid, either the amounts were not stated or the preservative was reported to have been present in traces only. The remarks already made as to the variability of methods and criteria for reporting, which are inevitable in a collected series such as this, must of course be borne in mind in considering these figures. It is possible that in the case of those analysts whose reports merely stated whether boric acid was or was not present, many of their samples may have contained considerable amounts ; the significance of the term " trace " doubtless varied with different analysts. The results of the examinations show, nevertheless, that boric acid has been found present in canned meats of British origin in a large proportion of samples taken from many different localities, and that in several cases it has been reported to have been present in considerable amounts.

The British samples in which sulphite preservatives were reported were few in number compared with those which contained borates. Sulphites also occurred less frequently in British samples than in those of United States origin. Among the former it will be noticed from the above table, that such meats as " tongues " and " fresh meats " were reported to contain this preservative more frequently than other British varieties of canned meat. This is in accordance with what has already been stated as to the use of sulphite sprays, &c., for revivifying meats in the joint or mass.

THE ADDITION OF PRESERVATIVES DURING PREPARATION.

It is obviously of the utmost importance, if the use of preservatives at the very outset is to be avoided, that the various meats used by the canner should be sound and fresh when purchased by him. In most cases, as already stated, care seems to be taken to secure this. The temptation, however, exists to obtain raw materials cheaply by purchasing at a time when fresh meats have reached the limit of their keeping powers. Various circumstances which from time to time come to light as the result of action by local authorities, suggest that a lucrative trade is sometimes done in meat of this kind, and that canned potted meat may be a convenient ultimate destination for such material. In such circumstances the meats would often require treatment with some kind of preservative in order to prevent decomposition manifesting itself before the manufacturing process could be begun.

Canned American and Colonial meats are largely used by some home manufacturers in making "potted" and other forms of preserved meats. Cans used for this purpose are in many cases those which have been dinted or otherwise disfigured in course of transit, and for this reason would not be acceptable to retail shopkeepers ; they are therefore sold by the consignee at a reduced rate, and are generally purchased by makers of potted meats, &c. It is not suggested that the contents of these cans are necessarily inferior, or unsuitable for this purpose. Such cans must be distinguished from those which are rejected by the consignee on account of decomposition of their contents, as evidenced by their characteristic "blown" appearance, or the presence of a puncture or other break of the hermetic seal. Attempts have been undoubtedly made in the past by unscrupulous persons to utilize tins of the latter kind in the manufacture of prepared foods. Potted meats and other articles made from materials of this kind would be likely to contain, besides heavy doses of seasoning material, a large quantity of preservatives.

It should be said here that of late years more care has been exercised by certain local authorities concerned, and also by consignees of canned goods themselves, to prevent unsound tins of imported meats from reaching the dealers. Arrangements exist both in Liverpool and London, the two chief ports of entry for these materials, by which the consignee, on surrendering unsound tins for destruction to the local authority, receives a certificate which enables him to claim allowance for the defective goods from the packer. Notwithstanding this, however, quantities of unsound canned food of various kinds find their way into this country from abroad. From time to time information concerning them reaches the sanitary authority in whose district they have been deposited, and recent seizures in the City of London and in several of the Metropolitan Boroughs of imported canned foods found to be in an unsound condition will serve to indicate the extent to which traffic in these articles may be engaged in. It is possible also that the traffic is not confined to unsound canned meats of foreign origin.

My inquiries among home manufacturers as to the deliberate addition of preservatives to canned meats in course of preparation were met in the great majority of cases by the statement that no preservative of any kind was added to their products. These manufacturers declared that the addition of preservatives to hermetically sealed goods, packed in either glass or cans, was quite unnecessary, and that the only advantage to be gained from the practice would be an extension of the time during which such articles would remain "fresh" after the tin or glass vessel had been opened. None of these manufacturers, however, referred to this advantage as being one of any special importance, complaints as to the lack of keeping properties of their products being rare and, in most cases, easily explained by carelessness of the purchaser, or an unreasonable notion on his part, as to the length of time such food materials might be expected to remain sound after the vessel in which they were contained had been opened. A certain number of manufacturers had only more or less recently abandoned the addition of preservatives to their products. They had taken this course, for the most part, owing to the "scare" about canned goods in 1906 or because of prosecutions by local authorities under the Sale of Food and Drugs Acts. Since discontinuing the practice none of the manufacturers with whom I spoke had experienced any difficulty in regard to the keeping qualities of their hermetically sealed canned or glass-packed goods. Their reasons for having used preservatives previously were not always very clear ; some stated that their object was to keep the meat from becoming tainted during the process of cutting up and preparation for canning ; others that the preservative was added to supplement sterilization by heat, in case the latter process should have failed; and some again could give no reason other than that the recipe according to which the article was prepared had contained instructions to add so much preservative.

Encouragement of practice by manufacturers of preservatives.—There is little doubt that the tendency towards adding preservatives to food materials of all kinds has been encouraged to a large extent by the manner in which manufacturers of the various boron antiseptics, and their agents, have pressed the claims of their preparations on those engaged in the various branches

of the trade in meat food products. These antiseptic materials are often sold under fancy names, with nothing to guide the purchaser as to their composition, and are often accompanied by a sort of guarantee to the effect that their use in accordance with directions given will not entail liability to prosecution. The great saving in trouble and material which is held out as an inducement to users of these substances, and the harmless, not to say beneficial, effects which they are stated to have on those who consume them in food, have no doubt had weight with a certain class of preserved meat manufacturer.

A small number only of manufacturers stated that they still added preservative, in the form of a "patent" boron preparation, to certain of their glass-packed goods. The goods in question were mainly potted meats, and the preservatives were said to be required either to prevent the meat from becoming stale during the process of chopping and grinding it into the required pasty condition, or else to ensure its keeping fresh in the glass pot in which it was packed. Although usually the material was said to have been hermetically sealed and subjected to a process of sterilization by heat, these manufacturers considered that it was quite impossible for them to prepare these meats, in the summer time at any rate, so as to remain fresh for any reasonable period, without the addition of boron preservative.

The amounts in which boric acid was added to canned meats by those firms who informed me of their practice in this respect, were not large. In one case, where the statement of the manufacturer as to quantities used was checked by analysis, the discrepancies between the two sets of figures obtained were, in most of the samples, small, though in two cases the amount found was considerably in excess of that which was stated to have been added. (*See* Addendum B.)

No instance came to my notice where amounts approaching the extremely large quantities reported in some of the samples referred to on p. 16 were employed. The presence of such quantities of boric acid in canned food can only be explained by supposing that a preservative had been shovelled into the mass in an altogether reckless fashion—a proceeding for which there would probably be some underlying reasons.

Manufacture of Canned and Glass-Packed Meats.

In order that the differences in practice among manufacturers, indicated above, may be explained, it will be necessary to consider the methods of manufacture as these are generally carried out in this country, and to indicate variations in conditions affecting them which may throw some light on the alleged necessity for adding preservatives to these materials. It will be convenient first of all to give some account of the general conditions which were found in the various factories visited.

Conditions of premises, apparatus, &c., which are likely to lead to the use of preservatives:—Some of the factories which I visited had been specially constructed for the preparation of canned foods, and were provided with sound cleansable flooring, good light and ventilation, and an adequate arrangement of the workrooms for carrying out the various stages of manufacture under favourable conditions. Others were little more than covered-in yards and converted outhouses at the rear of buildings which had originally fulfilled some other use. Here the conditions were not always favourable for cleanliness; the paving of the floors was often defective and capable of lodging dirt; gulley traps which had at one time been fixed in an open yard ultimately found themselves, as extensions were made, within the work rooms or sheds, and arrangements generally were seldom such as to render cleanly operations easy. Apart from structural advantages, the actual standards of cleanliness observed in different factories varied greatly. In some of the better constructed factories the minutest care was evidently given to details necessary for the protection of the food material handled, to the personal cleanliness of the operatives and their wearing apparel, to the cleanliness of tables, utensils and appliances of all kinds that came in contact with the meat, and other matters. In other factories of this kind the same degree of care was not observable. The arrangement of the

workrooms was sometimes bad. I have observed, for instance, in the same room a number of steam sterilizing retorts arranged round the greater part of its walls, while its centre and a part of one side were occupied by the tables and plant for cutting up, grinding and packing potted meats of various kinds. This room was lighted from the roof, and its high temperature, especially in summer time, would be enough, apart from any other gross contributory factor, to bring about putrefactive changes in the meats during the 12 to 24 hours or more that, in this instance, were said to be occupied in the process of preparing them for packing. The factory in which the above conditions were observed is one of those in which boric acid is used for the purpose of preventing decomposition from occurring in the materials during their manufacture.

In a few of the smaller factories where structural difficulties rendered the maintenance of good conditions by no means easy, I have sometimes been able to note that great pains were taken to protect the meat materials from contamination during the process of manufacture. In one or two instances the workpeople were provided with clean cotton overalls and had facilities for washing; the tables were sound and clean, and where the kind of work performed at them permitted, were fitted with marble or enamelled iron tops; utensils and apparatus were also kept in a satisfactory condition. The method, also, of dealing with the food materials was orderly and expeditious, in so far as this was possible in a factory where all the various processes were carried out in workrooms which were little more than separate corners, or areas of a large straggling shed, divided from each other imperfectly, or not at all. Such factories were, however, always open to objection on the score of their structural defects. The inlet of a drain communicating directly with any room is always objectionable and is the more so when the room in question is one where food is prepared. Besides the dangers which may arise from the escape of sewer gas into a workroom through defective traps situated in its floor, there is sometimes the possibility in low-lying districts, during bad weather, of the sewage flowing back through traps of this kind and invading the factories.

In other of these converted workplaces, however, the conditions found have been more in accordance with what might be expected from their defective construction. Lumber covered with dust had in some been allowed to accumulate in corners or annexes of the general workshop, which was itself often dilapidated and far from clean. Tables and utensils used for the preparation of the meats were frequently in such a condition as to render it impossible to keep them clean. I have noticed in some of these factories the blades of chopping and mincing machines that had not been in use for some days, still coated with dried particles of the meats that had last gone through them.

In many of the factories sufficient attention did not seem to be paid to the danger of objectionable contamination which arises from placing open utensils containing meat materials on the floors of workshops. Substances like these, left for any length of time in such a position, can hardly escape fouling by dust raised by or dirt splashed from the boots and garments of the workpeople employed. In some instances the standard of cleanliness observed among the employees was much below what ought to be maintained in places of the kind.

Preparatory pickling of meats.—In certain classes of canned meats, such as corned and pressed beef, tongues, brawns, &c., the meat employed undergoes a preparatory pickling in brine. This process is usually carried out on the premises of the manufacturer, and preservatives may or may not be used in the pickling fluids. In all those cases where inquiry was made on this point, I was informed that no preservative, other than the usual salt, saltpetre and sugar, was used in these brines. Where meats treated in this way are fresh to start with, and proper precautions are observed in their management while in pickle, there appears to be no necessity for charging the pickling fluid with boric acid or other antiseptic.

Cooking, cutting and preparing.—Before reaching the stage at which the meat materials are finally placed in their glass or tin receptacles ready for

sterilization, they are generally partially cooked and are then boned out and cut into portions of suitable size. During the latter process, especially in the case of potted meats, opportunity for contamination may arise from such avoidable circumstances as uncleanly handling, high temperature of the room in which the work is carried out and insufficient despatch in getting the meat through this stage of its manufacture. Conditions like these may, as has been said, occasion the addition of boron preservative to meats at the earliest stage of manufacture in order to prevent putrefactive changes from occurring before the process of sterilization can be carried out.

The despatch with which the preparation of potted meats is got through in different factories varies considerably. As short a time as from 2 to 4 hours was stated by one manufacturer to be sufficient, while another informed me that the preparation of his potted meat materials previous to the sterilizing process frequently took as long as 36 hours. Where handling operations are extended over so long a period, and where perhaps other conditions are unfavourable, it is hardly to be wondered at that the addition of preservatives is found necessary in order to prevent the material from "going sour" before it can be finally sterilized.

Enough has probably been said in the foregoing paragraphs to indicate the kind of conditions met with in different factories which affect unfavourably the keeping powers of the meats dealt with.

It is apparently owing to the presence of one or more of these remediable faults that some manufacturers have had recourse, during the summer months at any rate, to the use of preservatives in canned goods requiring considerable manipulation, such as potted meats, galantines, brawns, &c. Such articles as corned beef and tongues, which require less manipulation and are exposed to adverse conditions for much shorter periods than the above-mentioned meats, generally escape the dangers to which the latter may be exposed. I have not found any instance in which the manufacturer has declared it necessary to add preservatives to his corned beef and tongues during this stage of their preparation.

Packing in Tin and Glass.

After the various meats have been cooked and trimmed, or cut into small pieces, they are placed in their receptacles and in certain cases, *e.g.*, brawns and tongues, a gelatinous fluid is poured in to fill up any interspaces that may occur in the container. Potted meats, which have been chopped or ground to a very fine consistency, and are at this stage in the form of a thin dough, are packed in their receptacles by means of a machine similar to that used for filling sausages.

In the case of canned goods the lids of the cans are now soldered on, and glass vessels are fitted with metal lids of different patterns. In some factories potted meats packed in glass or earthenware jars are sealed by means of a stout cork and foil capsule.

The representatives of certain firms of manufacturers whom I visited informed me that they were obliged to resort to the use of preservatives in some of their products owing to difficulties which they experienced in regard to a particular type of glass container which was used by them.

One of these difficulties was said to be the unreliability of the air-tight joint formed between the metal cap and the body of this container. I was informed by one manufacturer that owing to this defect many of his potted meats had gone bad and had been returned to him by shop-keepers. In order, he said, to avoid this occurrence, it had been his practice for some time past to add 0·5 per cent. of a boron preparation to his potted meats.

Another firm complained of excessive breakage in this form of container when effective sterilisation was attempted. They had been obliged, they said, for this reason to supplement sterilization of their potted meats by the addition to them of 0·25 per cent. of boric acid.

Types of tin and glass containers.—Until recent years most of the preserved foods manufactured in this country were packed in tin-plate receptacles. Tin-plate is a convenient material for this purpose, as an efficient seal can easily be procured in vessels made from it and no special disadvantage arises from subjecting them to high temperatures, thus enabling sterilisation* of their contents to be readily effected. Besides this, tin-packed goods are much more easily and safely transportable, and occupy less storage space than vessels of an equal capacity made from glass or earthenware. For these reasons tin plate is still used in the packing of almost all preserved foods imported into this country, and also of many of those exported from it. It has been supplanted of late years to a very large extent, however, by glass and earthenware, more especially the former, in the case of goods intended for the home market. Several circumstances have probably been at work in bringing about this change. In the first instance the substitution of glass for tin was doubtless prompted by a desire to avoid metallic contamination of the contents. The glass container also enabled the purchaser to see something, at any rate, of the material he was buying, and the manufacturer was not slow to seize this opportunity for adding to the attractive appearance, as well as to the price, of his product, by employing materials of a better quality than were generally used in canned goods, and by arranging them with more care in the containers. In this way glass-packed meats soon increased in popularity, and notwithstanding increased cost of production due to higher price of glass receptacles, loss from breakage, &c., the home manufacturer is still enabled to compete in British markets with foreign makers, who are obliged to confine themselves to the production of tin-packed goods.

So much have glass-packed food materials advanced in public favour, that it appears to be profitable for certain home manufacturers to transfer imported canned meats, such as tongues, sardines, &c., from their tin receptacles into glass containers. I witnessed this process being carried out in one fairly large factory, and was told that it formed a considerable part of this firm's business.

Tin containers.—With a view to minimising the risks which might attend absorption of injurious metals by the contents of canned foods, many improvements in the construction of tin-plate receptacles have been introduced. These have been mainly in the direction of diminishing the use of solder in their constructions, contact of food materials with the solder being rightly regarded as objectionable. An improvement of this kind is the punched-out or moulded can, the only joint in which is that between lid and body. The soldering of this joint is performed in such a way as to prevent the solder from appearing on the inside of the can.

In some factories the use of solder in making this joint is done away with altogether, and the lid is fixed to the body of the can by a process in which the folded edges of the lid and the can are firmly clamped together in a special machine. It is claimed by those who employ this pattern of can that the joint so formed is quite as strong and as air-tight as ordinary soldered joints. A difference of opinion, however, exists among manufacturers on this point. In cans of the ordinary type, in which the various parts are secured by solder, the joints are generally so planned as to minimise the amount of solder appearing on the inner surface of the tin and coming into contact with its contents.

The chief source of considerable metallic contamination in most canned goods of ordinary age, is probably to be ascribed to metal or soldering fluid which has escaped into the contents of the can in the operation of closing the vent-hole. Most better class manufacturers provide against this accident by fixing a solder trap, consisting of a small cup-shaped piece of tin, to the lid of the container immediately beneath the site of the vent-hole. This precaution may, however, not be taken. As will be mentioned later, a second aperture may in

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* The term is here used in the limited sense in which it is generally employed by manufacturers, viz., to indicate the capacity which exposure to heat confers on hermetically sealed goods to remain sound for indefinite periods without the assistance of added chemical preservatives (*see* p. 26).

some cases be made in cans in order to allow of a third stage of the sterilizing process, and as this additional vent-hole is not as a rule provided with a solder trap, particles of metal may readily gain entrance to the meat through it. The practice of unsoldering the original vent-hole, as carried out in some factories where it is customary to employ a third stage in the retort, is perhaps the safer way when one solder trap only is provided in the lid.

In one factory which I visited, some of the smaller tin receptacles for potted meats, &c., were being made without having recourse to the use of solder for any purpose, the lid being clamped on to a moulded jointless body in the manner above referred to and the usual blow-hole being omitted. Such tins when finished would not, of course, have the usual vacuum, but if they are properly sterilized and if the solderless joint possesses the reliability which is claimed for it, there is no reason why they should not give satisfactory results as regards the keeping qualities of their contents.

When a good quality of tin plate is employed in making receptacles for meat foods, and suitable precautions are taken for preventing the accidental introduction of solder, or soldering fluids, into their interiors, the metallic contamination that would result, in the case of most meat foods of reasonable age, would probably be small. If properly prepared and fastened with these precautions, such vessels should, moreover, keep hermetically sealed for almost indefinite periods.

Glass containers.—Glass vessels used for packing meats are of various shapes and designs, from the long jar-shaped vessel with narrow orifice to the flat wide dish. Much care and ingenuity have been expended in devising caps for these vessels which will provide a reliable air-tight seal after their contents have been subjected to the process of sterilization. In the case of the various metal caps which are in use, the seal is effected by means of a rubber washer placed between the opposing surfaces of the glass vessel and the metal cap. When sufficient sustained pressure is exerted between the cap and the vessel the joint is rendered air-tight, and will remain so as long as the pressure is exerted and the elasticity of the rubber is not destroyed. The necessary sustained pressure for securing this air-tight seal is obtained in one of two ways, which are represented by two distinct types of metal cover.

The "Automatic" cap.—In the first and most generally employed of these, which is known as the "automatic cap," the necessary pressure is obtained by producing a partial vacuum within the vessel during the sterilizing process. The cap in this type is a simple metal lid, which closely fits the rim of the glass container and bears upon a rubber washer interposed between them. A steel spring clamp holds the lid temporarily in position while the vessel and its contents are being sterilized, but the clamping force of this spring is regulated so as to permit of the escape of contained air together with the steam which is generated during the process. After the sterilizing process is completed and the temperature of the vessel falls again to that of the surrounding atmosphere, the contraction of the contained air and condensation of vapour which follow, produce sufficient negative pressure within the vessel to hold the lid firmly in position.

It will be seen from the above that the cap remaining fixed in position in this type of cover, is dependent on the joint being an air-tight one. If the joint were not perfect in this respect, the vacuum would disappear, and the cover would become loose and would drop off at the first handling. The formation of gases of putrefaction within the container would also neutralize the atmospheric pressure on which the fixation of its lid depends, and would cause the lid to become detached. These are characteristics which necessitate attention to cleanliness and proper handling in course of packing, and special care to obtain adequate sterilization where this type of container is used, and are strong points in its favour for these reasons. I have not met with any cases in which the necessity for using preservatives was alleged, when the "automatic" cap was employed.

The "Phœnix" cap.—The second type of cap is one which depends on a mechanical contrivance for the sustained pressure which is needed in order to

maintain an air-tight joint. The " Phœnix " cap may be taken as an example of this type.

This cap is used only when the orifice of the vessel is comparatively small, and in the meat-preserving trade is employed almost exclusively for " potted " meats. It consists of a lid which is surrounded by a metal band, the upper margin of which embraces the edge of the lid, while the lower margin is free. A rubber washer accurately fitting the lid is placed within it, and in some cases a sheet of tin foil is fixed so as to lie between this washer and the rim of the vessel to which the cap is applied. This use of tin foil adds greatly to the efficiency of the joint by filling any irregularities which may be present on the surface of the glass, and also serves to separate the materials contained in the vessel from contact with the rubber band. The pressure necessary to form an air-tight joint with this cap is applied by means of a specially constructed press. The force employed should vary with the circumference of the cap, and should be sufficient to compress the rubber to about one-half its original thickness. At the moment of maximum pressure the lower free margin of the metal band is flanged on to an annular projection of the glass near the rim of the vessel, and in this way the cap is permanently fixed to the glass container at whatever pressure may have been applied to it.

When the various steps have been carefully carried out, a joint formed in this way should be perfectly air-tight and capable of resisting any bursting force which is likely to be generated during the process of sterilization. It should be noted that a bursting force equivalent to the pressure originally applied in the machine press would not unseal the joint when properly made: a much higher force would be required to overcome the resistance offered by the metal flanging. In such containers formation of gases of decomposition would produce somewhat similar results to those observed in hermetically sealed tins, that is to say, some slight bulging of the lid would occur and a hollow sound would be produced on tapping it. Detachment of the lid would not follow as in the case of the " automatic " cap.

Some potted meat manufacturers complain that glass vessels fitted with this cap suffer much more breakage during sterilization than those in which the " automatic " cap is employed. They attribute this to the fact that during this process, considerable pressure is generated within the former, while in the latter no internal pressure is produced. The maximum temperature to which the majority of glass-packed goods are exposed during sterilization is 100° C., and the pressure generated at this temperature in a vessel sealed in the manner of the " phœnix " cap, would amount to less than $1\frac{1}{2}$ atmospheres, a force that in itself would not be capable of bursting properly annealed glass vessels of the size generally used. With an inferior quality of glass, however, the tendency to break on application of heat would be increased by the presence of an internal pressure of this amount. As already mentioned, one manufacturer informed me that he was obliged to mix boric acid with his potted meat materials for the purpose of supplementing the sterilizing process, in order to avoid the excessive breakage which resulted from exposing vessels with this type of cap to a temperature that was sufficient to preserve their contents. His excuse for continuing to employ the cap in these circumstances was that it is in favour with the public and to abandon its use might be detrimental to his trade.

The majority of manufacturers with whom I spoke on the subject did not, however, consider that the use of the " phœnix " cap caused excessive breakage in their glass containers. They were able, they said, to sterilize satisfactorily the contents of vessels in which this cap was used without greater loss than was experienced in the case of glass containers fitted with the " automatic " cap, and they had never found it necessary to employ chemical preservatives in order to supplement their sterilizing process.

Sterilization.

The process of final cooking and sterilization employed by manufacturers varies according to whether the containers dealt with are made of tin or of glass. The usages of different factories also contribute to variety in the details of the processes.

Open vat process.—This is the older method, which is still in vogue in some factories, and is used chiefly for sterilizing canned meats. After the cans have been packed and the lids soldered in position they are placed in a steam-heated vat or bath of calcium chloride solution, sufficiently deep to cover all but the upper half inch or so of the cans. This liquid has a boiling point which is generally above 110° C. (230° F.), and it is covered with a thin layer of fat to prevent the escape of steam from its surface. When the cans have been placed in position the temperature of the vat is raised to a point a little below its own boiling point and above that of water, with the result that steam is soon generated in the tin containers and blows off through vent-holes which have been left open in the lid of each can. After a period which varies with the size of the can and the custom in vogue at the particular factory, this first step in the process is brought to an end. The cans are removed from the vat, and as the jet of steam from the vent-holes diminishes, the latter are closed by running a drop of solder over each. In this way the cans are hermetically sealed and, as the steam with which they are more or less filled at the moment of sealing condenses on cooling, a partial vacuum is formed in each can. The production of a vacuum is the main object of this first stage of the process.

The second stage of sterilization by this method consists in immersing the hermetically sealed can in a vat of the same temperature as before for a given period, which is, as a rule, considerably longer than that allowed for the first stage. When this period has elapsed sterilization is generally considered to be completed, though in some factories it has been the custom in certain instances to re-puncture the lids of the cans, allow the steam generated therein to escape, close the newly made vent-hole with solder and subject the tins to a further period of heating.

The idea that a condition of vacuum within the can was necessary for the preservation of hermetically sealed foods had its origin, no doubt, in the belief which is apparently still entertained in some factories, that atmospheric air has, in itself, the power of bringing about decomposition in meats with which it remains in contact. In the majority of cases, however, it is very unlikely that all the air contained in the can and entangled in its contents is displaced by the processes above described. But the presence of a partial vacuum in vessels containing food materials may serve some useful purposes. Putrefactive changes which may be set up in the contents of such cans, owing, for example, to imperfect sterilization, will, in the majority of cases, be attended by development of gas ("blowing" as it is called), and this sign is more readily perceived on account of the disappearance of the original concavity of the ends of the cans to which the vacuum gave rise. The partial removal of air from cans probably also allows of the more rapid and uniform conduction of heat through the mass of meat contained in the vessel, and in this way may contribute towards better results as regards sterilization.

Steam-heated Retort Process.—In most modern factories steam retorts have taken the place of calcium-chloride vats, though in some the two systems are combined, the vat being used for the first stage of the process, and the retorts for subsequent stages. The type of retort most commonly used is the single jacketed autoclave, heated with steam from a boiler. The retort is generally fitted with both pressure gauge and thermometer, and has supply and exhaust taps by which the pressure of steam within the apparatus may be regulated.

The steps in the process of sterilizing canned goods in the steam-heated retort are similar to those described in connection with the calcium-chloride vat, the first stage consisting in a gradual raising of the pressure within the retort until a temperature is reached at which the steam generated in the can will blow off freely at atmospheric pressure. When the desired temperature has been maintained for the required period, the pressure in the retort is rapidly lowered to that of the atmosphere, the retort is opened, the cans are removed, and, as the issue of steam from the vent-holes is about to cease, they are sealed with solder. The cans are then returned to the retort to undergo the second stage of the process, that of sterilization proper. During this stage they are exposed to a certain temperature for a certain period, at the end of which sterilization is supposed to have been completed, or, as described in the open vat

process, they may now be re-punctured * and subjected to a third heating in the retort. In some factories this third stage is employed in the case of most canned meats, while in others it is reserved for the larger cans only.

As may be gathered from the foregoing description the guides which seem to be generally relied on at this stage to indicate that sterilization has been successfully carried out, are the records of temperatures and times which have been observed in the retorts or vats themselves during the process. The data upon which these times and temperatures seem to be based will be referred to later.

Sterilizing glass receptacles.—As in the case of canned articles, the process of sterilizing glass-packed goods may be carried out either in the open vat or by means of the steam retort. The process with glass, however, consists of one stage only, and it is carried to completion in whichever of the two systems is adopted. The temperature to which glass vessels are exposed during sterilization is generally much lower than is the case with cans. Thus, the open vat which is used for glass goods is most frequently a simple water bath with a normal boiling point of 100° C. (212° F.), and where the retort is used this degree of temperature is in most cases not exceeded and in some it is not even reached.

High temperature as a cause of breakage.—Most of the manufacturers with whom I have spoken referred to the difficulties which are said to attend the exposure of glass vessels to high temperatures. Even with the comparatively low temperature employed in the majority of factories the breakage of vessels in the vats, and especially in the retorts, is considerable, averaging in some cases as much as from 3 to 6 per cent. This breakage is ascribed partly to imperfect annealing of the glass vessels and partly to too sudden variations in the raising or lowering of the temperature to which the vessels are exposed. The breakage from these two causes increases in proportion as the maximum temperature employed in the process is increased, and it is mainly for this reason that the lower temperatures mentioned are those more generally employed.

High temperature affecting appearance of meat. —This, however, is not the only reason why high or even moderate temperatures are avoided by some manufacturers in treating certain meats after they have been packed in their glass receptacles. Potted meats and other finely minced materials containing a large percentage of fat, are liable to suffer somewhat in appearance from really effective sterilization. Small bubbles are frequently formed in the minced meat during the process, and the fat which it contains separates out to a certain extent and forms, on cooling, a whitish layer in the upper portion of the jar. In cans and in earthenware vessels changes of this kind do not matter, as they cannot be seen by the purchaser, but in glass vessels it is different, and I understand that some purchasers are inclined to look upon these appearances with suspicion, whereas in reality they are valuable evidence that an honest attempt had been made to sterilize the material.

I was told by one manufacturer who aimed at "thorough sterilization" of his potted meats after packing them, that he did not understand how some firms were able to obtain such an even and homogeneous appearance in their glass-packed potted meats. He had himself, he said, tried by every means, short of not sterilizing them, to secure results similar to theirs, but had failed.

There can be little doubt that with some manufacturers of potted meats the "sterilization" which their glass-packed goods undergo is of a perfunctory character. Thus, in a certain fairly large factory, I had the opportunity of observing the containers in course of being filled with the meat, fitted

* It is this practice that accounts in the great majority of cases for the second soldered vent-hole which may be seen in many tins. The occurrence of a second vent-hole in cans has frequently been referred to as an indication that they were at one time "blown" by gases of putrefaction, and subsequently punctured, resoldered, and dishonestly issued as sound. This is by no means necessarily the case, but the practice of making a second vent-hole for the much more general and perfectly legitimate object above referred to, is not in itself desirable unless a solder trap has been provided beneath the site of the second puncture as well as beneath that of the first.

with their covers, and finally labelled. I observed that these three operations followed each other at a series of tables all in the same room. There was, apparently, no removal of the vessels after sealing to some other part of the building where sterilization might have been done without my observing it, and it is highly improbable that this process would be performed after the labels had been attached. This firm admitted using 0·5 per cent. of a borax preparation in their potted meats, explaining their doing so on the ground that the joint of the Phœnix type of cap which was employed could not be made perfectly air tight. In consequence, they said, the contents of the vessels were liable to contamination after they had been sterilized, and in hot weather would soon become decomposed if a preservative were not used. The real explanation seemed to be that in order to retain the homogeneous appearance of their potted meats, or for some other reason, this firm refrained from sterilizing them at all, and relied for their preservation on the boric acid employed.

Criteria of sterilization by heat.

Notwithstanding the considerable diversity which has been observed in the practice of different manufacturers, the results obtained by those who rely on exposure to heat for preserving their goods may, on the whole, be considered satisfactory so far as the attainment of this object is concerned.

The term "sterilization" as used by manufacturers of canned and glass-packed goods must not, however, be taken in its absolute sense. As it is generally used in connexion with these materials the term simply refers to the process of heating hermetically sealed vessels containing meat which confers on them the capacity to remain "unblown," and, when opened after some time, to present a sound appearance, taste, and smell. These properties are, of course, prime essentials in the successful production of such goods, and when attained may be taken as an indication that certain saprophytic bacteria which are responsible for the degenerative changes normally occurring in meat, have been rendered incapable under ordinary conditions of producing these effects. The criterion taken does not necessarily insure the destruction of pathogenic organisms, should these be present, much less does it imply destruction of the more resistant spore-bearing bacilli, or that complete absence of living organisms which the term "sterilization" in the bacteriological sense connotes. A considerable number of the canned meats reported upon in the returns made to Dr. Buchanan in 1906 were found to contain living organisms, although they were apparently free from putrefactive changes.

Criteria usually taken.—In the majority of factories the process of cooking and so-called "sterilization" is conducted by a foreman who relies on his past experience for guidance as to the various details that should be observed in the process, in regard to vessels of different makes and sizes and containing different kinds of meat. To his individual judgment is left, in most cases, decision on such important points as the temperature at which the process should be conducted and the length of time during which the vessel should be exposed to this temperature in order that the mass of meat which it contains may be rendered free from putrefactive organisms. In some factories provision is made for checking the efficiency of the process in this respect by placing a sample from each batch of goods in a warm cupboard or room, and observing after a week or so whether or not "blowing" has occurred in the cans, or whether the caps of glass-packed meats have become affected. Other manufacturers rely for the detection of faulty results on the sorting which takes place when their goods are being sent out, after having been deposited in storerooms at ordinary temperature for longer or shorter periods. The percentage of rejections which is said to occur as a result of these measures is very small; in most of the factories which I visited it was stated not to exceed 0·01 per cent., and such results might seem sufficient justification for the somewhat haphazard and inexact methods by which they are attained.

There are, however, certain advantages in attaching a stricter significance to "sterilization" than that above described. If living organisms are left, exposure of the can to circumstances favourable to their growth may lead to "blowing" and

decomposition at later periods, although no sign of this has been present when the can leaves the factory, or when the sample of the batch to which it belonged was kept in the warm room. There is also the important question of destroying disease-producing organisms, should these have been introduced by the meat or as a consequence of its handling and packing. Cases of fatal illness, undoubtedly caused by living organisms of the type of *Bacillus enteritidis* of Gaertner, which have a low heat resisting capacity, have, for example, been referred to the consumption of canned meat in which no obvious signs of putrefaction were observed.

Many manufacturers argue that these considerations should not be pressed too far, and that nothing in the way of a standard of bacteriological sterility should be required in meats of this kind. The reasons put forward in support of this view are that the spore-bearing germs which are occasionally found in canned meat at the present time are generally harmless and that an attempt to eliminate these and to insure absolute destruction of all organisms in the contents of the vessel would necessitate such intense or prolonged application of heat, that goods so treated would be over-cooked to an extent that would render them unsaleable. It may be admitted that the great majority of spore-bearing organisms likely to be present in canned meats are of no importance from the consumer's point of view. But the spore-bearing class includes organisms such as *B. anthracis*, *B. botulinus*, and possibly some other forms which have been associated with acute intestinal disease in man. If it is agreed that the manufacturer should so regulate his sterilization as uniformly to ensure the destruction of non-sporing gas-producing and pathogenic organisms, it seems also desirable that the times and temperatures employed should, whenever possible, be increased to the point necessary to ensure the destruction of sporing micro-organisms also. The objections on the ground of over-cooking were not, so far as I could ascertain, based on the results of actual experiment. On the contrary, in the one instance which came to my notice, where an attempt had been made to study the various factors governing sterilization of canned and glass-packed materials, and to put this very important process on a sound footing, the apprehended difficulties do not seem to have been met with.

An improved system.—The factory in which the experiments referred to were conducted is a large one, and the firm employs a properly qualified chemist who, in addition to his other duties, has control of the sterilizing plant. The opportunity thus offered for placing the process of sterilization on a more scientific footing was taken advantage of, and a series of experiments was commenced with this object. The criterion for efficient sterilization was taken to be the maintenance of a given temperature for a given length of time, *at the centre of the meat in its receptacle*, the times and temperatures adopted being those which were calculated to kill spore-bearing organisms.* Experiments were made with can and glass containers of various sizes and with different kinds of meat. In the centre of each of these vessels a small self-registering thermometer was placed and observations were made of the retort temperatures and periods of exposure that were required to maintain the desired degree of heat for the necessary length of time *at the centre of each can or glass receptacle.* Observations were made

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* Most of the commoner forms of non-sporing pathogenic bacteria will not survive exposure in moist media to a temperature of 70°C. (158°F.). Exposure to a temperature of 110°C. (230°F.) under similar conditions for five minutes was assumed to be sufficient to destroy all organisms and their spores and this time and temperature were used in the factory referred to for all canned goods and for the smaller glass packed articles also. With the larger glass containers, however, lower temperatures had to be employed and the time of exposure proportionately extended : thus in retorts the maintenance of a temperature of 101·6°C. (215°F.) for one hour at the centre of glass packed meats is taken as the standard. In water vats the highest available temperature 100°C. (212°F.) is required to be maintained at the centre of the meat for at least two and a half hours.

In connexion with this matter reference should be made to a recent paper by Major W. W. O. Beveridge, D.S.O., R.A.M.C., and Captain H. B. Fawcus, R.A.M.C., in the Journal of the Royal Army Medical Corps (March 1908), which shows that a particular gas-producing, spore-bearing bacillus—*B. cadaveris sporogenes*—is so resistant that it would not be destroyed by the exposures above given. Fortunately, however, spores of this bacillus appear not to become active until a temperature approaching 37°C. (98·6°F.) is attained in the medium in which they are present.

at the same time in regard to the behaviour of steam as a source of heat in retorts, and the circumstances in which the heat applied is best conducted by the vessels and their contents were also investigated. Certain errors in the methods which had previously been employed were discovered and rectified. As a result of the observations which were made a table was prepared for the guidance of the retort man, giving the retort temperatures and corresponding periods of exposure which were calculated to bring about the desired results in the various meats dealt with. The value of these tables is, I understand, frequently checked by means of a thermometer packed in a marked vessel which is placed in the retort along with a batch of vessels of the same kind for sterilization. I am informed that the working of this system has so far yielded very satisfactory results.

If what may be considered a reliable working system of sterilization, like that above referred to, can be attained in practice by the adoption of a satisfactory criterion and improved methods, it is very desirable that such a system should come into more general use, and this not only in the interests of consumer, but also in those of the manufacturers themselves. For there can be little doubt that the process of sterilization at present carried out in most factories, based as it is on rule of thumb methods, may not only be sometimes inefficient in the way referred to, but is also likely to be wasteful as well. This might be expected to be the case especially where steam retorts are used and where the well-known difficulties regarding the behaviour of steam as a source of heat are left to the imperfect knowledge of the ordinary retort man to deal with.* The result in many cases is just as likely to be that heat in excess of what is necessary will be applied as that the temperature obtained in the centre of the contents of the vessel will be insufficient.

SECTION IV.

General Review and Conclusions.

It will be convenient here to set out some of the principal conclusions which it appears desirable to draw from the valuable information forwarded to the Board by public analysts and other officers under the Sale of Food and Drugs Acts, as the result of the sampling of meat foods under these Acts which took place in 1906, and from the various inquiries which I have since made into the subject.

(1.) Preservatives in Imported Canned Meat Foods.

The finding of preservatives in a considerable proportion of American and other imported canned meats, examined by public analysts in this country, is a matter of importance from a public health aspect. The question is not merely one of the ill-effects likely to be produced in persons who, in this way, consume what may possibly be large doses of these substances or who, by taking these foods, add unnecessarily to the total quantity of antiseptic substances in their diet. The chief objection which may be raised to preservatives occurring in meat foods which have been subjected to the process of sterilization by heat in hermetically sealed vessels, is that the presence of preservatives must be regarded as indicating that conditions as to care and cleanliness which are essential in the preparation of wholesome food materials may not have been observed.

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* In course of the experiments regarding sterilization above referred to, it was found that the temperature and pressure employed in the steam retorts, sustained for the period considered necessary by the retort man, produced a temperature of only 87·7° C. (180° F.) at the centre of certain cans. But by allowing a small wastage of steam from the exhaust tap of the retort, and in this way securing circulation of vapour within the chamber, a temperature of 110° C. (230° F.) was obtained at the centre of the cans under the same conditions of time, temperature, and pressure in the retort itself.

Dr. Eugene H. Porter, Commissioner of Health of the State of New York, has referred to this matter in the following terms* :—

> "The use of any preservative in a food to be enclosed in a can which can be satisfactorily sterilized by the use of heat and sealed hermetically, indicates that the materials to be placed in the can were in such a state, or were kept under such conditions, as to lead the canner to believe that they required the use of a preservative for the prevention of decomposition until they could be safely canned.
>
> "The finding of a boron preservative in a sample of "potted ham" in which were found numbers of the *Trichina spiralis*, clearly indicates that in the minds of those who prepared this meat, it required a preservative in order to prevent its decomposition before it could be sterilized in the can.
>
> "It is not easy or always possible to ascertain from an examination of a sample of canned meat containing a preservative whether decomposition had set in at the time the preservative was added or not, but the possibility or the probability of the development of such undesirable changes must have been present or the preservative would not be added."

The views expressed above undoubtedly offer the correct explanation of the circumstances which lead to the presence of boron compounds in foods of this kind in the great majority of cases, and it is difficult to accept the explanations in this matter which are commonly given by representatives of canning firms (*cf.* p. 6).†

Similar considerations may be said to apply to sulphite preservatives. These seem to have been reported more frequently in American canned meats than in those of British manufacture, and though there are chemical and analytical conditions which impair the value of quantitative analytical results obtained in regard to them, the fact that sulphites are frequently found in canned meats cannot seriously be questioned, and their presence can only suggest the same interpretation as that just given.

Extent of protection afforded by foreign and colonial laws.—The United States Meat Inspection Act of 1906, which was the outcome of inquiries made into this, together with other aspects of the American meat-packing trade, prohibits the use of artificial preservatives in meat and meat food products, and it may be hoped that the very comprehensive and stringent provisions contained in that measure are already having, or will have, the effect of abolishing those practices which lead to the use of chemical preservatives in canned meats.

Legislation as to supervision of the preparation of meat foods in various States of Australia, in New Zealand, and more recently in Canada may also be alluded to as probably affording a substantial check on the use of preservatives in canned meat foods which are subject to official supervision in those Dominions.

It must, however, be remembered that the extent to which foreign and colonial laws and regulations regarding canned foods are likely to be and to remain operative in practice in the case of exports to the United Kingdom, depends very largely on the efficiency of precautionary measures taken in this country. At a time when systems of official inspection, regulation and certification in connexion with the manufacture and preparation of meat foods are being rapidly developed in foreign countries and British Dominions, there would appear to be special advantage in specifying British requirements in such a way that foreign and colonial manufacturers and officials are in no doubt as to what the public health authorities in Great Britain expect them to avoid or to do in regard to the use of preservatives in canned meats exported to this country, and in arranging some systematic method of analytical control for the purpose.

(2.) Preservatives in Meat Foods Canned or Packed in Glass in the United Kingdom.

Preservatives in the Raw Materials.

Boric acid in large amount has been found in canned meats of British manufacture, as the result of employing meats imported from abroad in

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* Monthly Bulletin, New York State Department of Health, May 1907.

† The accidental addition of boric acid in consequence of the use of a salt which naturally contains small quantities of the preservative would in most cases introduce mere traces of boric acid into the finished product—quantities, for example, which, if estimable at all, would be under one grain in a pound of canned meat.

this preservative.* Convictions have been obtained by local authorities under the Sale of Food and Drugs Act in such cases. But the number of instances coming to the notice of these authorities in which amounts of boric acid are sufficiently large to ensure successful prosecution is necessarily small and forms but a slight check on the practice of employing such meats for canning purposes.

The second and larger class of meats which come under this head are bacon and hams. These are meats which in normal circumstances are cured by means of salt and saltpetre, and occasionally sugar. The process of curing renders the meat more or less immune to the influences of putrefactive organisms according to the length of time during which the meat has been kept in "pickle." It was the custom formerly to continue the curing process for a sufficient length of time to insure that when removed from the pickle and properly dried, hams and bacon would remain sound for long periods. They were, however, liable to be affected in various ways where conditions as to curing or storage were faulty. Thus putrefactive processes like "taint," and contaminations such as flyblow were accidents which required constant guarding against by bacon curers.

When borax came into use as a preservative it was found that these conditions were prevented by sprinkling the surfaces of the meat with powdered borax. Later this substance came to be used as a constituent of the pickle, and it was found that by employing the preservative in these ways the curing process could be shortened without to a corresponding extent endangering the keeping qualities of the meat. The lessened salty flavour of hams and bacon which followed the introduction of these methods appears to have met with favour among consumers generally, and it has since been the aim of most bacon and ham curers to produce materials as mildly cured as possible. In these circumstances the use of boric acid has come to be regarded by many bacon manufacturers as a necessity, more especially where their products have to be kept for long periods or are intended for distant markets. On the other hand, some well-known British manufacturers declare that no such necessity exists, and that they are able to prepare, store and export their products to all parts of the world without having resort to boron preservatives, or other antiseptics, at any stage.

Before the use of borax was introduced for the purpose mentioned above, hams and bacon were sent from the United States to this country packed in salt. This method of transport amounted practically to a continuation of the curing process for a number of weeks longer than was the custom in the case of home cured materials and, owing to their consequent increased saltness, American hams and bacon suffered greatly by comparison with British produce in the home market. The use of borax in the manner above mentioned has enabled American and Canadian curers to send their produce to Great Britain in a condition which, as regards "mildness" of flavour, complies with the taste of consumers in this country.

Borax-packed Hams and Bacon as a source of preservative in Canned Meats.

The amount of boric acid found in bacon and hams imported under the above conditions will depend on whether the preservative has been employed only as a packing material, or has in addition been used in the curing of the meat. Examination of samples of hams said to have been only packed in borax, shows that amounts varying from 2·6 to 13·5 grains per pound of the minced and mixed ham may result from mere contact with the preservative in the packing cases. Larger quantities than this, up to 24 grains per pound, of boric acid, were mentioned to the Departmental Committee on Preservatives and Colouring Matters† as having been found in hams, and the Committee refer to this as an indication that boric acid had been used in the curing of these products.

Since the passing of the United States Meat Inspection Act the use of borax in hams and bacon sent to this country is said to have been confined to external application as a packing material. Generally it may be said that this

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* Dr. Buchanan's Report, *loc. cit.*, p. 8. † Report, p. xxvi, par. 110.

use of borax is free from the objection that the preservative has been used to mask the effect of objectionable conditions of preparation, etc. It may be sufficient in this connexion to observe that if the use of boron preservative in food were to be restricted with the object primarily of limiting the *number* of foods which at present may contain this preservative, and were to be confined to such foods as in present circumstances appear to demand borax as an essential condition of trade, a good case would be made for permitting the continuance of borax packing in the case of American and Canadian hams and bacon, provided the amount of preservative absorbed by the meat was not excessive.* On the other hand no trade necessity can be alleged for using borax in the curing process itself, a view which is borne out by the fact that for some time past American manufacturers have apparently been able to dispense with this use of the preservative.

The amount of preservative which may be found in certain varieties of canned meats, due to their having been manufactured from hams and bacon in which boric acid had been employed solely as a packing material, would in most cases be small and of little importance as a public health consideration. But it would be necessary to take account of such small quantities of preservative in any scheme which might be arranged for controlling the use of preservatives in canned meats. If potted meats made from imported hams were exempted from any restriction as regards preservatives that might be applied to canned meats in general, such exemption would be certain to afford a convenient plea for manufacturers who desired to continue the improper use of boric acid in potted meats, and the difficulty of administration would be greatly increased in such circumstances. It should be remembered in this connexion that hams and bacon which are free from preservative can be obtained in British markets, and that some well known manufacturers, in order to ensure the freedom of their products from boric acid, have already taken the precaution of using only those American hams and bacon which are sent to this country in salt packing and guaranteed to be free from chemical antiseptics. Apparently an unlimited supply of these salt packed hams could be had if demanded, and for a price not greater than that charged for borax packed materials. Danish bacon free from borax is also available, and it could no doubt be arranged by potted meat makers who desired it, to obtain bacon and hams of British origin which did not contain any preservative of this kind.

Addition of Preservatives by the Canner.

As already stated the presence of boric acid in canned goods of British manufacture may to a certain extent be attributed to sources referred to in the foregoing. In a great number of instances, however, the presence of preservative in these materials cannot, for various reasons, be explained in this way. Such is the case with, for example, many of the "potted meats" which have been shown by analysis to contain exceptionally large quantities of boron preservative. Notwithstanding the fact that these materials are in most cases mixtures of two or more meats and often contain in addition a large percentage of farinaceous matter, the amounts of boric acid found in them have frequently been much greater than is ever likely to be found in raw material of the kind above-mentioned from which they might have been made. The only possible explanation of the presence of preservatives in such circumstances is that they have been deliberately added to the material in process of manufacture.

It has been indicated in section 3 of the report that the use of meat which has become, or is on the point of becoming tainted may lead to the use of chemical antiseptics (as by immersing in fluids, spraying or powdering) for the purpose of preserving it. It has also been shown that even where sound materials are used to start with, faulty, dilatory and uncleanly methods of manufacture may so far affect the condition of the meat previous to packing that the use of antiseptics has to be resorted to.

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* *Cf.* p. 9 *et seq.*

It will be gathered from descriptions given in preceding pages that the various steps in the manufacturing process of canned and glass packed goods are operations which require considerable skill and care. In handling the perishable material dealt with great cleanliness is needed and every convenience for securing this and for enabling the various steps to be carried out with despatch, is essential if the material is to reach the consumer in a wholesome condition. In the majority of the factories visited care seemed to be taken to ensure that these essential requirements were observed. Reference has, however, been made to instances in which one or other important point was not attended to. A few of the factories were, indeed, quite unfitted for the use to which they were put. Places hidden away among the dilapidated buildings of dingy streets or beneath remote railway arches —sometimes even within the same curtilage as premises in which offensive trades are conducted—cannot be considered fit for the preparation of food material intended for human consumption. The structural defects of such places are sufficient in themselves to render the cleanly preparation of canned meats in them impossible, but when, in addition, as is frequently the case, the appliances used at these factories, and the workpeople who use them, are of no higher standard of cleanliness than the buildings themselves, it is not difficult to understand the need which arises for means which will counteract in some way influences so adverse to the preservation of the meat used.

I found many grades of greater or less efficiency between such entirely undesirable food factories and others which could be pronounced without hesitation to be satisfactory in all essential respects. But neglect of some obvious precaution, such as the necessity for carrying out certain stages in the manufacture speedily, and under suitable conditions of temperature, &c., may render unavailing the care taken in other steps of the process, and may lead to the addition of preservatives at this stage.

There is a tendency on the part of some manufacturers to leave the technical details of their business too much in the hands of the workmen who carry them out.* Many of these workmen look upon the details of the processes which they are conducting as technical secrets of their own, and resent any interference with the preconceived notions which they may have regarding them. A manufacturer who has not a well-grounded knowledge on these matters, or who, while possessing this, fails to insist on his ideas being carried out, is at the mercy of his foremen. The latter are in some cases content to proceed with the methods in which they were brought up, and are naturally inclined to continue practices which protect them from the consequences of miscalculations or mistakes. The use of antiseptics from their point of view, posseses this advantage, and it is not to be wondered at that when given a free hand, they should avail themselves of it.

Greater Use of Preservatives in Glass-packed Meats.

The use of chemical antiseptics is especially undesirable in the case of meat foods packed in glass, which have lately come into much favour with the public. Many complaints were made during my inquiry as to the difficulties which had to be overcome in connexion with the manufacture of meats so packed. The chief of these was the difficulty experienced in the sterilizing process, of steering a middle course between the risk of breakage on one hand, and that of insufficient sterilization on the other. This is doubtless an operation requiring care and experience. Most manufacturers, however, have been able to carry it out with success, so far as the conferring of keeping qualities on their meat is concerned, and some of them have even stated that they experience no difficulty whatever in the matter. The question seems to be entirely one of efficient technique, and to avoid the danger by adding sufficient antiseptic to preserve the packed material against the consequences of faulty sterilization, amounts to a pretence and cannot be justified. A still more unjustifiable practice is that which has been referred to of adding boric acid to potted meats hermetically sealed in glass, in order to avoid sterilising them at all. To sell meats prepared in this way in hermetically sealed containers, which purport to be preserved by means of heat, or are of a pattern which the purchaser generally associates with goods preserved in this way, is a

* *Cf.* page 26.

form of deception which may be prejudicial to the health of persons consuming them.

The alleged inefficiency of certain forms of metal caps for producing an hermetic seal with the glass containers for which they are designed is, I am convinced, unreal. Complaints as to this were made only by those who, either from fear of breakage, or in order to preserve the homogeneous appearance of their potted meats, sterilized these products imperfectly or omitted the process altogether. Many of the better manufacturers had no difficulty with these covers, and were able to rely with considerable certainty on their process of sterilization alone to preserve the meats sealed by means of them.

It is undoubtedly more difficult to produce meats properly preserved by means of heat in glass containers than in cans. The high temperature to which canned materials may be subjected for long periods without risk renders the sterilization of such meats a much more certain process than is the case with glass-packed goods. None of the manufacturers whom I saw had experienced any real difficulty in preserving their canned products by means of heat, and all denied using preservatives, or the necessity for using them, to supplement this process in canned goods. To this extent canned meats in general might be said to possess advantage, from the point of view of wholesomeness, over meats which are packed in glass. On the other hand, the difficulties met with in sterilizing glass-packed meats necessitate the observance of greater cleanliness and care in their preparation (*so long as preservatives are not added*) if satisfactory results are to be obtained. Added to this is the fact that their contents are more or less capable of inspection by the purchaser, and are for this reason very unlikely to contain any of the grosser contaminations which have been reported in some American canned foods, for example.

The freedom of glass-packed meats from liability to metallic contamination is another point which may be noted in their favour, though the practice among some British manufacturers of re-packing in glass imported meats which have just been turned out of their cans for the purpose, is calculated to shake the confidence of those who rely for protection in this respect on buying only meat preserved in glass containers.

(3.) Administrative considerations in regard to Preservatives in Canned and Glass-packed Meats (*imported or home-prepared*).

On review of the above, it seems desirable that steps should be taken to secure that specified chemical preservatives should not be used in the preparation of canned meats intended for consumption in this country. In any schedule of prohibited preservatives, boron compounds,* sulphites and preparations of sulphurous acid, benzoic acid and formalin should, I think, be included.

The action which for this purpose may be recommended for the Board's consideration is such as could apparently be made available by the issue of suitable regulations under the Public Health (Regulations as to Food) Act, 1907, made applicable (1) to imported canned foods at the ports of entry; (2) to manufacturers in this country of meat foods which are packed in cans or glass. Should regulations be prepared with this object (either as a separate series or as part of a larger series dealing with preservatives in a variety of food-stuffs), it would seem desirable to make due allowance for trade requirements in the matter of existing contracts, stocks on hand, and so forth.

(4.) Additional Observations.

In concluding this section attention may be directed to certain matters which have incidentally come into prominence as a result of my inquiries :—

(*a*) *Proprietary antiseptic preparations.*—It seems desirable that manufacturers of meat foods should refuse to purchase any preparations offered to them

* In determining the significance of results obtained from analyses of canned and glass-packed meats for boric acid, traces not exceeding one grain per pound, might fairly, I think, be discounted in order to allow for possible contamination from such harmless and accidental sources as, for example, the naturally impure salt referred to in earlier sections of this report. Such provision would not lessen the necessity for care on the part of manufacturers in selecting their materials, and would certainly not permit of the deliberate addition of boric acid to the foods in question.

for the purpose of treating meat in storage or of adding to meat preparations or brines unless they are fully assured as to the composition of any preparations so offered.

(*b*) *Labelling.*—So far as my inquiry has been concerned with the question of labelling and marking of canned foods, it has brought into prominence the fact that the custom which at present prevails in this matter in many cases does not permit the origin of particular tins of canned meats to be traced further than to the middleman or importer. In some cases (including to my knowledge at least one in which the wholesomeness of the foods was open to very serious question) neither the can nor the label bears any name or other mark by which it can be referred to retailer, middleman, manufacturer, or anyone at all. Reform in the trade custom in this respect seems on many grounds desirable.

(*c*) *Admixture of starch with potted meats.*—Starch, usually in the form of rice flour, is sometimes present in such amounts in some kinds of potted meats that these may be thought to constitute a fraud on the consumer notwithstanding their cheap price. The matter seems worth the attention of better class manufacturers with a view to arriving at a reasonable maximum limit of permissible starchy matter in specified canned foods of this class.

(*d*) *Preservatives in sausages, &c.*—Some of the objections above set out to the use of chemical antiseptics in canned meats apply also to such articles as sausages, pork pies, mincemeats, brawns, and the like, which are not preserved by canning or cold storage, but in the ordinary course of trade may be kept for several days on the shop counter and similar places. If on the ground of public convenience and trade requirements the use of chemical antiseptics is permitted in these articles, it appears very desirable that their employment should be restricted within narrow limits. Quantities of boric acid are not seldom reported by public analysts in some of these goods which cannot be otherwise than prejudicial in themselves, besides being wholly unnecessary. If boron preparations are used for this purpose, a limit of $\frac{1}{4}$ per cent. of boric acid would probably be ample to meet legitimate trade requirements, and even in this case it appears desirable to consider whether notification of the presence of the preservatives should not be given to the purchaser. The practice of using solutions of sulphurous acid or sulphites as a spray or wash, or for mixing with the meat, appears to be open to many abuses and to be generally undesirable.

(*e*) *Places where food is prepared.*—The Board have recently received representations from several sources to the effect that stricter sanitary supervision and control should be exercised by local authorities in this country over premises on which meat foods are manufactured and over the processes of preparation employed on such premises. It has likewise been urged that all practicable steps should be taken to require evidence from official sources as to the inspection or supervision in foreign or colonial establishments whence meat foods are imported into the United Kingdom. The inquiries above recorded have brought out many circumstances which appear to support these views.

A. W. J. MacFADDEN.

G. S. Buchanan,
Inspector of Foods,
Local Government Board.

May, 1908.

ADDENDUM A.

Boric Acid content of Borax-packed Hams.

Report by Mr. P. A. Ellis Richards, F.I.C., on the analysis of certain hams of United States origin, said to have been cured without the use of borax, but which were exported to this country in borax packing.

Description of the hams examined will be found in the accompanying table.

Preliminary treatment in the laboratory.—The surface of each ham was first washed and brushed, and then the skin was carefully removed and weighed.

A section was next made through the thickest part of the ham, commencing at its lean underneath surface, and carried through the thickness of the ham as far as the fatty covering on its upper side. From this section transverse portions were cut out at different distances from the surface with a view to determining the extent of penetration of the boric preservative. The proportions of the latter in the fat and in the skin were separately determined. Finally the rest of the ham, with the exception of the skin and bone, was minced, thoroughly mixed, and an analysis made of the amount present in the minced mass.

The lean portion was sub-divided as follows :—

(1) The external half-inch layer
(2) The next layer up to 2 inches deep
(3) „ „ from 2–3 „ „
(4) „ „ „ 3 „ to fat layer.

Results of analyses.—The following table gives the analytical results obtained, the boric preservative present in all cases being estimated as crystallised boric acid (H_3BO_3) and reported in grains per pound.

Observations.—The skin was entirely removed from each ham before mincing, its exact weight taken in grams, and its approximate corresponding weight in ounces recorded.

It will be noticed that the quantity of boric acid that found its way into the fat was small, and as the proportion of the latter present in each ham differed considerably, the analyses after mincing show varying amounts of boric acid. Another factor influencing the average amount was the degree of penetration in the lean portion. As an example of this, in the case of Nos. 3 and 4, it is interesting to note that although the proportion of boric acid in the external layer was about the same, yet the degree of penetration was much greater in No. 4 than in No. 3. This naturally caused a smaller average amount in No. 3, and this decrease was still further accentuated by the larger proportion of fat present.

Examination of a ham (No. 7) which had been packed in salt only.—A section was cut from this sample as in the previous instances, but no evidence of boric acid could be obtained from any portion of the ham.

(Sd.) P. A. ELLIS RICHARDS.

Chemical Laboratory,
Charing Cross Hospital,
May 10th, 1907.

TABLE I.

Description of Sample.	(1.) Dry Salt Cure. Packed in Borax. Date of Shipment, 29th March, 1907. Tested April 24th.	(2.) Sweet Pickle Cure. Packed in Borax. Date of Shipment, 27th March, 1907. Tested April 24th.	(3.) Sweet Pickle Cure. Packed in Borax. Date of Shipment, 29th March, 1907. Tested April 24th.	(4.) Sweet Pickle Cure, Packed in Borax. Date of Shipment, 21st March, 1907. Tested April 24th.	* (5(*a*).) Packed in Borax. Tested April 26th.	* (5(*b*).) Packed in Borax. (Cooked before analysis.) Tested April 26th.	† (6(*a*).) Packed in Borax. Date of Shipment, 24th Feb., 1907. Tested April 27th.	† (6(*b*).) Packed in Borax. Date of Shipment, 24th Feb., 1907. (Cooked before analysis.) Tested April 27th.
Skin—								
Total weight	310 grams (about 11 ozs.)	270 grams (about 9½ ozs.)	250 grams (about 9 ozs.)	180 grams (about 6¼ ozs.)	455 grams (about 16 ozs.)	Skin removed.	305 grams (about 11 ozs.)	Skin removed.
Boric acid per lb.	21 grains	13·3 grains	15·8 grains	24 grains	20·14 grains	—	13·2 grains	—
Fat—								
Approximate amount	Fair amount.	Fair amount.	Considerable amount.	Less fat than (3).	Large amount.	Less amount.	Small amount	Fairly lean.
Boric acid per lb.	1·73 grains	1·5 grains	1·35 grains	1·62 grains	1·75 grains	1·73 grains	1·6 grains	1·47 grains
Lean—								
Boric acid per lb.—								
Outside layer, ½ in. thick	22·1 grains	28·2 grains	36·4 grains	35·4 grains	45·1 grains	26·4 grains	22·4 grains	19·35 grains
Next layer, ½ to 2 in.	14·7 „	18·8 „	12·3 „	35·0 „	23·1 „	17·5 „	22·4 „	19·0 „
Next layer, 2 to 3 in.	14·5 „	16·1 „	3.85 „	22·5 „	6·9 „	7·1 „	18·2 „	15·7 „
Up to lower surface of fat layer	7·9 „	5·9 „	2·2 „	15·0 „	4·7 „	4·7 „	12·9 „	6·24 „
Average amount of boric acid per lb. found in the whole minced ham.	3·1 grains	4·5 grains	2·6 grains	8·4 grains	5·2 grains	7·12 grains	13·5 grains	8·4 grains

* The date of shipment in the case of 5(*a*) and 5(*b*) was not ascertained. These two samples were taken from the same case in which they were packed side by side.

† The last two samples, 6(*a*) and 6(*b*) were said to have been in cold air store in their cases with borax packing for a month previous to samples being taken. They were not frozen hard, but simply chilled.

Addendum B.

Boric Acid content of certain Potted Meats.

Report by Mr. P. A. Ellis Richards, F.I.C., on the analysis of certain potted meats hermetically sealed in glass containers, to which it was stated by the manufacturer that definite quantities of a "patent" boron preservative had been added, with analysis of the preservative in question.

All the samples were examined for preservative, and if found, the amount of the latter was estimated, The preparations of meat afforded no evidence of the presence of sulphites, formalin, salicylic or benzoic acids, but each sample with one exception contained boric acid.

The following table sets out the description of the meats, the amount of antiseptic said to have been added, and the quantities actually found in each case estimated as crystallised boric acid :—

Description of vessel's contents.	Amount of "patent" preservative stated to have been added by manufacturer, grains per lb.	Amount of boric acid found, in grains per lb.
"Salmon and shrimp"	14	27
"Chicken and ham"	14	28
"Wild duck"	14	13
"Turkey and tongue"	14	9
"Veal and ham pâté"	Nil.	Nil.
"Salmon and anchovy paste"	Nil.	14

The meat preparations were examined for excess of iron, but the amounts present were all small, varying from 0·007 per cent. of oxide of iron in the case of the "wild duck" sample to 0·02 per cent. in the sample of "salmon and shrimp."

Analysis of the patent preservative used in the above :—Qualitative examination showed that this was a mixture of desiccated borax and boric acid. No starch was present. Quantitative analysis gave the following results :—

Boron trioxide (B_2O_3)	60·3 per cent.
Sodium oxide (Na_2O)	7·2 „ „
Water	32·5 „ „

The probable composition of the powder was therefore :—

Anhydrous borax	23·4 per cent.
A mixture of boric and pyroboric acids ...	76·6 „ „

Assuming the powder to have been originally made from crystallised borax and boric acid, the mixture being fused and powdered, the actual proportions of the crystallised substance taken would have been about one part of borax ($Na_2B_4O_7$, $10H_2O$) to two parts of boric acid (H_3BO_3).

(Sd.) P. A. Ellis Richards.

Chemical Laboratory,
Charing Cross Hospital,
13th February, 1907.

Addendum C.

Sulphite in Sausages.

Report by Mr. P. A. Ellis Richards,, F.I.C., on the sulphurous acid content of certain sausages to which a known quantity of this preservative had been added by the manufacturer in accordance with his usual custom.

It was stated that half a gill of a solution of calcium bisulphite had been added to 37 pounds of the sausage meat.

The sausages were made in the presence of Dr. MacFadden, and an analysis of them was undertaken about three hours later. From the strength of the calcium bisulphite employed it was calculated that each pound of sausage meat would have had originally added to it approximately 0·46 grains of sulphurous acid (SO_2). The amount found after three hours was 0·40 grains per pound. After three days an estimation of the sulphurous acid present was again made and it was then found to have fallen to 0·21 grains per pound. After six days (the sausages being then distinctly sour) the quantity present was 0·17 grains per pound.

(Sd.) P. A. Ellis Richards.

26th February, 1907.